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RESEARCH REPORT

Factors that influence development of speech pathology skills required for videofluoroscopic swallowing studies

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Abstract

Background: Perceptual, cognitive and previous clinical experience may influence a novice Videofluoroscopic Swallowing Study (VFSS) analyst's trajectory towards competency. Understanding these factors may allow trainees to be better prepared for VFSS training and may allow training to be developed to accommodate differences between trainees.

Aims: This study explored a range of factors previously suggested in the literature as influencing the development of novice analysts' VFSS skills. We hypothesised that knowledge of swallow anatomy and physiology, visual perceptual skills, self-efficacy and interest, and prior clinical exposure would all influence VFSS novice analysts' skill development.

Methods & Procedures: Participants were undergraduate speech pathology students recruited from an Australian university, who had completed the required theoretical units in dysphagia. Data assessing the factors of interest were collected—the participants identified anatomical structures on a still radiographic image, completed a physiology questionnaire, completed subsections of the Developmental Test of Visual Processing—Adults, self-reported the number of dysphagia cases they managed on placement, and self-rated their confidence and interest. Data for 64 participants relating to the factors of interest were compared with their ability to accurately identify swallowing impairments following 15 h of VFSS analytical training, using correlation and regression analysis.

Outcomes & Results: Success in VFSS analytical training was best predicted by clinical exposure to dysphagia cases and the ability to identify anatomical landmarks on still radiographic images.

Conclusions & Implications: Novice analysts vary in the acquisition of beginner-level VFSS analytical skill. Our findings suggest that speech pathologists who are new to VFSS may benefit from clinical exposure to dysphagia cases, sound foundational knowledge of anatomy relevant to swallowing and the ability to see the anatomical landmarks on still radiographic images. Further research is required to equip VFSS trainers and trainees for training, to understand differences between learners during skill development.

KEYWORDS
andragogy, dysphagia, training, VFSS

WHAT THIS PAPER ADDS

What is already known on the subject

- The existing literature suggests that no vice Video fluoroscopic Swallowing Study (VFSS) analysts training may be influenced by their personal characteristics and experience.

What this study adds

- This study found that student clinicians, clinical exposure to dysphagia cases and their ability to identify anatomical landmarks relevant to swallowing on still radiographic images prior to training best predicted their ability to identify swallowing impairments after training.

What are the clinical implications of this work?

- Given the expense of training health professionals, further research is required into the factors that successfully prepare clinicians for VFSS training, including clinical exposure, foundational knowledge of anatomy relevant to swallowing and the ability to identify the anatomical landmarks on still radiographic images.

INTRODUCTION

Dysphagia is a term that describes the difficulty or an inability to swallow, arising from an underlying medical cause (Speech Pathology Australia, 2012). The prevalence of dysphagia in the general population has been reported to be approximately 12% (Kertscher et al., 2015) and is higher in the elderly population, particularly following stroke and dementia (Rajati et al., 2022). In the acute hospital population, dysphagia is associated with lower weight and strength, a longer hospital length of stay, higher inpatient costs, a higher likelihood of discharge to post-acute care facility and inpatient mortality (Melgaard et al., 2018; Patel et al., 2018). The videofluoroscopic swallow study (VFSS) is a radiographic instrumental assessment that is routinely used to evaluate swallow function. VFSS assessment requires speech pathologists to integrate their understanding of swallowing physiology with their subjective perceptual assessment of the flow of the bolus and the movement of the structures involved in swallowing. This informs management recommendations and rehabilitation (Swan et al., 2019).

Analytic skill is essential for effective, safe and efficient VFSS. The speech pathologists' decision-making in the moment can affect the quality of the VFSS data collected. Conducting VFSS can be stressful, and not all speech pathologists develop the skill (Duivestein & Gerlach, 2011). While training approaches vary according to facility and the professional standards of each country, often the final training in VFSS is provided in the workplace (Edwards et al., 2019).

VFSS analysis, like other medical imaging procedures, requires the speech pathologist ('the analyst') to inspect the image and to provide an interpretation (Krupinski, 2010). This requires both visual perceptual skill and cognitive skill (Krupinski, 2010). Search strategy and pattern recognition are known factors that influence medical officers' accuracy when interpreting radiological images (Krupinski, 2010). The ability to 'see' can vary according to a person's speed and ability to recognise visual patterns and to encode, retain and retrieve this information (Abernethy et al., 1994). This ability to retain and recognise visual information improves with expertise and practice (Abernethy et al., 1994).

The radiology literature suggests that the ability to analyse images develops faster and plateaus earlier than interpretation and factual knowledge (Waite et al., 2019). The clinician is required to detect an abnormality, recognise when that difference is pathologic, discriminate the nature of the difference and reach a diagnosis (Waite et al., 2019). The efficacy of detection underpins the latter steps; a foundational skill is the knowledge of what requires attention and what can be ignored (Waite et al., 2019). It is hypothesised that the detection of an anomaly activates the clinician's cognitive schema, applying prior knowledge of images and theory. Based on this knowledge, the clinician builds an expectation of what might be seen next.

Conducting a comprehensive VFSS requires the analyst to analyse a complex moving image. The speech pathologist uses their visual perceptual and cognitive skills to conduct a preliminary analysis in the radiography suite to hypothesise which compensatory strategies may be useful to immediately trial. After the study is completed, without the direct time constraints experienced during the study, the analyst reviews the images and conducts quantitative measures with frame-by-frame viewing and synthesises all the information to describe the features of the swallow observed.

VFSS interpretation is complex. An essential skill required to decode the VFSS image is the ability to describe the movement of the anatomical structures and their influence on the path of the bolus. This skill requires both an understanding of the underlying physiology and anatomy of swallowing, as well as the ability to cognitively interpret translucent two-dimensional images as the actual interacting three-dimensional structures to predict their influence on the bolus (Krupinski, 2010; Robb, 2000).

Trainers of VFSS competencies have suggested that speech pathologists across disciplines vary in their ability to analyse spatial resolution (i.e., see fine detail), manage low contrast detectability and analyse temporal resolution to track the bolus on VFSS, which may influence their trajectory towards competence (Edwards et al., 2019; Silbergleit et al., 2018). Later in training, the ability to synthesise and interpret information, flexibility, the capacity to formulate hypotheses based on real-time analysis of swallowing and to trial and evaluate compensatory strategies, and the capability to convey the main findings are valued highly in combination with the ability to apply knowledge of anatomy and physiology according to the best evidence (Edwards et al., 2019).

In addition to these perceptual and cognitive factors, the literature has identified other learner factors that may influence VFSS analysts' development. Clinical experience, motivation, commitment, and self-reflection have been put forward as indicators for success in achieving VFSS competency (Duivestein & Gerlach, 2011; Edwards et al., 2019; Nordin et al., 2017). Novice analysts report varying interest and confidence as they enter training (Smith et al., 2010). Trainers consider outcomes to be better when novice analysts are interested and have confidence that develops further in training (Edwards et al., 2019). However, there may be other factors that are potentially remediable prior to entering practice in the VFSS suite. For example, trainers posit that prior excellent knowledge of healthy and disordered biomechanics is important for skill development, and that clinical experience may facilitate successful VFSS training outcomes (Edwards et al., 2019). Similarly, clinical experience is known to improve accuracy and efficiency in radiology, particularly for less salient abnormalities (Waite et al., 2019).

Understanding the learner factors that influence positive outcomes for novice analysts from VFSS training is both clinically and theoretically important. Knowing which factors influence development may allow VFSS trainers to provide useful preparation activities or tailor VFSS training appropriately for individuals. Novice analysts may also benefit from understanding the factors that may influence their competency development. Bandura (1977) proposed that a person's expectation of success—their self-efficacy—influences their perseverance and ultimate performance. Understanding the factors that influence training may allow learners to identify skills that can be improved, potentially increasing the expectation of eventual success. Exploring the range of factors that are involved may also allow researchers in the field to avoid confounding influences related to analysts' cognitive and perceptual skills in studies requiring perceptual VFSS rating.

Aims and hypotheses

This study explored the range of factors previously suggested in the literature as influencing the development of novice analysts' VFSS skills. We hypothesised that knowledge of swallow anatomy and physiology, visual perceptual skills, self-efficacy and interest and prior clinical exposure would all influence VFSS novice analysts' skill development. The beginner-level skill of interest was the ability to indicate on a checklist the disordered biomechanics visible in a study.

METHODS

Data were collected simultaneously as part of a randomised control trial (RCT) described in detail elsewhere (Edwards et al., 2022). The purpose of this RCT was to compare the effectiveness of three different training modes (independent online, peer-supported, and expert-facilitated) on the development of VFSS analytic ability for diagnosis of dysphagia. In the RCT, participants completed 15 h of training over 5 days, comprising a computerised introduction to VFSS analysis and practice rating films. The participants were randomly allocated across three training conditions: independent online study (where the training material was completed at home alone), peer-supported study (where the training was completed in small groups), and expert-facilitated study (where the training was completed in small groups with a facilitator). To measure the effect of the training, the participants analysed three VFSSs pre- and post-training and were rated for accuracy against the consensus ratings of credentialed speech pathologists. Ethical approval for the study was obtained from The Australian Catholic University Human Research Ethics Committee: 2017–244ERC.

Participants

The participants were 97 undergraduate speech pathology students from one Australian university with campuses in three states. The participants provided written informed consent in response to an emailed invitation to 430 students who had completed the swallowing and mealtimes curriculum required for their degree. The prior knowledge of the group of participants was therefore similar, but clinical experience varied according to the participants' year in the programme and the placements they had completed at the time of training. There was a high rate of attrition before data collection began: 23 final-year students withdrew from the study prior to training as 17 had gained full-time employment, one was unable to access childcare and 5 did not provide a reason for withdrawing. Recruitment began at the end of an academic year and included students who had completed their final assignments and were waiting to graduate. Students were able to find work in this period, contributing to the high number of participants the withdrew before training commenced, predominantly in the first year of the study. The mean age of the 74 participants that commenced and completed training for the RCT was 23.85 years (SD = 6.64). There was a predominance of women (70 women to four men) consistent with the underrepresentation of men in the speech pathology profession in Australia (Skeat et al., 2022). A complete data set was available for 64 of these participants. Providing the VFSS training to this group of participants enabled the learner factors to be compared without the possible influence of different workplace experiences, training or professional development.

Measures

The dependent variable was the participants' ability to correctly identify disordered swallowing biomechanics, as rated in time-limited presentations of three VFSSs after training. While the participants had a checklist, they did not have time to complete this tool systematically. A free search was employed, appropriate for the dynamic nature of VFSS (Bryant et al., 2012). The participants' results were measured against a standard, which was the consensus ratings of three experienced VFSS-trained speech pathologists. The standard was 27 identified impairments. No clinical information was provided to the participants or experienced VFSS-trained speech pathologists.

Immediately prior to their first training session, all participants completed a range of tasks designed to assess the learner factors hypothesised to influence training outcomes for novice analysts.

Clinical exposure

The participants reported the number of clients with dysphagia that they had seen on clinical placements throughout their undergraduate course.

Ability to identify anatomy

The participants were asked to identify eight anatomical structures indicated by an arrow or highlight on a still radiographic image: the hard palate, tongue (anterior), angle of mandible, base of tongue, upper oesophageal sphincter, epiglottis, valleculae, and posterior pharyngeal wall (Logemann et al., 2000). Students received one mark for each structure correctly identified (spelling was not assessed) for a total score out of eight.

Knowledge of physiology

The participants completed a 13-question multiple choice test assessing fundamental swallow physiology that the participants had been taught previously in their undergraduate course. To ensure the questions were unambiguous, three speech pathology academics trialled a draft version of the test. Only questions for which there was unanimous agreement between the academics' answers were included; the data for two questions were removed from the data set due to ambiguous wording, as identified by the academics. Each question had multiple answers that were correct. Students received one mark for each

TABLE 1 Descriptive statistics—post-training impairment identification accuracy and pre-training learner factors

Measures*	***N***	**Minimum**	**Maximum**	**Mean**	**SD**
Impairment identification after training	72	6	24	15.64	3.795
Pre-training measures of potential influences					
Anatomy	73	1	7	3.82	1.584
Physiology	73	2	29	17.29	7.097
Analysis confidence	71	0	71	29.68	19.115
Learning confidence	72	8	100	70.93	20.388
Interest	72	50	100	89.50	12.868
Exposure	74	0	80	10.23	14.530
Figure-ground	74	3	12	8.12	1.880
Visual-closure	74	8	16	14.49	1.295
Visual-speed	71	14	65	36.73	10.125
Valid *N* (listwise)	64				

*Measures—Notes.
Impairment identification: Swallowing impairments correctly identified (Post-training).
Anatomy: Anatomy test raw score (out of 8) (Pre-training).
Physiology: Physiology test raw score (out of 43) (Pre-training).
Analysis confidence: Confidence in VFSS analysis (rating from 0–100) (Pre-training).
Learning confidence: Confidence in ability to learn (rating from 0–100) (Pre-training).
Interest: Interest in VFSS (rating from 0–100) (Pre-training).
Exposure: Number of dysphagia clients seen previously during clinical placements (Pre-training).
Figure-ground: DVTP-A Figure Ground subtest (Raw score) (Pre-training).
Visual-closure: DVTP-A Visual-Closure subtest (Raw score) (Pre-training).
Visual-speed: DVTP-A Visual-Motor Search subtest (Raw score) (Pre-training).
Abbreviations: DVTP-A, Developmental Test of Visual Perception–Adolescent and Adult; VFSS, Videofluoroscopic Swallowing Study.

item correctly identified, for a total score out of 43. The swallow physiology test questions are provided as an Appendix.

Self-efficacy and interest

The participants responded to the following statements on a visual analogue scale, anchored from strongly disagree to strongly agree, and graded from 0 to 100:

- I am confident in my ability to analyse VFSS.
- I am confident in my ability to learn to analyse VFSS.
- I am interested in the analysis of VFSS.

Data were collected using Qualtrics web-based software (Qualtrics, 2021). The number of returns for each variable is provided in Table 1.

Visual perception

Participants completed three subtests from the Developmental Test of Visual Perception–Adolescent and Adult (DVTP-A; Reynolds et al., 2002). The DVTP-A is a normative assessment with established reliability and validity that measures visual perceptual and visual-motor skills. The three subtests administered were selected because of their relevance to the skills required for VFSS:

- *Figure Ground* subtest—participants were shown stimulus figures and asked to find as many of the figures as they could on a page where the figures were hidden in a complex, confusing background. This was similar to the ability to detect a feature of interest (e.g., the bolus, a specific anatomical structure) from background information required in VFSS.
- *Visual Closure* subtest—participants were shown a stimulus figure and asked to select the same figure from a series of incompletely drawn figures. This was similar to the ability to extrapolate incomplete visual information required in VFSS, where a clinician views a limited, 2D representation of a bolus moving through and around the three dimensions of multiple anatomical structures.
- *Visual-Motor Search* subtest—participants were given a page covered in numbered circles. They had to connect the circles with a line in number order as quickly as possible. The visual-motor search requires the ability to separate out figures from the background with the additional pressures of motor control and speed. This was similar to the rapid visual processing required in VFSS.

A modified administration process was used to allow group rather than individual administration. The participants completed the visual perception assessment independently in small groups. The visual stimuli for the Figure Ground and Visual Closure subtests were presented via a data projector on a class-sized screen in a darkened room. Responses were recorded by students using a Qualtrics survey to enable automatic marking. The participants were video recorded with an iPad while completing the Visual-Motor Search subtest on the published response form, and then timed individually.

Statistical analysis

Due to the non-standardised administration of the DVTP-A subtests, standardised scores were not calculated and raw scores for each subtest were compared.

Planned analyses included correlations for each of the variables and a stepwise linear regression. The regression analysis was used to analyse the relative influence of each factor on skill acquisition following the training (Thrane, 2020). The regression considered all participants in one cohort as there was no significant difference in outcomes relating to the three training conditions of the randomised control trial (Edwards et al., 2022). Post hoc, the correlations between the factors of interest and the pre-training assessment results were also determined to ensure the findings related to training. All statistical analyses were conducted in Statistical Package for Social Science (SPSS) version 27 (IBM Corp., 2019).

RESULTS

Data screening

A complete data set was available for 64 of the 74 participants. The data for three participants were discarded due to the failure of video recording for the visual-motor search assessment. One participant was unavailable for the pre-assessment due to childcare responsibilities. The remaining missing data related to items in the pre-questionnaires that were not completed by participants.

Predictors

Descriptive statistics for each measure are reported in Table 1. The participants entered training with a wide variety of swallowing knowledge and experience on clinical placements, as evidenced by the range of results for the anatomy and physiology pre-assessments and exposure to dysphagia cases. While confident in their ability to learn, and interested in the skill to be acquired, the participants were not confident in their current analytical ability.

Three statistically significant, moderate to weak correlations between predictor variables and the outcome were found. The ability to identify impairments after training correlated with the participants' ability to identify anatomy on radiographic still images before training (r = 0.306; $p < 0.001$), exposure to dysphagia cases on placement (r = 0.389; $p < 0.001$), and pre-training interest in analysis (r = 0.250; $p < 0.05$). The weak correlation between the participants' physiology assessment and their response to training was not statistically significant (r = 0.221; p = 0.078). The correlation between the outcome and predictor values and between predictor variables are reported in Table 2.

Regression analysis

We next performed stepwise model comparison. This process selects only the predictors that incrementally improve model fit. The final model to predict the identification of swallowing impairments, as shown in Table 3, included only Exposure and Anatomy. Although this model was shown to be significant, it is important to note that the R-square, 0.193, was still quite low.

The participants' pre-training ability to identify anatomy from still radiographic images and their clinical experience with dysphagia clients were most predictive of their performance in VFSS analysis post-training.

Post hoc analysis

To explore the consistency of the relationship between the independent variables and performance in VFSS analysis, and to confirm a relationship between the variables and the training, correlations were also run for the pre-training measure of the identification of disordered swallowing biomechanics impairment identification for comparison. The correlations, plus the change in correlations after training, are presented in Table 4. This table shows that none of the learner factors assessed pre-training were correlated with participants' pre-training ability to identify impairments. The relationship was significant only for the post-training outcome.

DISCUSSION

This study explored the range of learner factors that may influence the development of VFSS analytical skill. Trainers of VFSS suggested the following influences on

TABLE 2 Intercorrelations between predictor and outcome variables

Measures*	Impairment identification	Anatomy	Physiology	Analysis confidence	Learning confidence	Interest	Exposure	Figure-Ground	Visual-Closure	Visual-Speed
Outcome										
Impairment identification		**0.306****	0.221	0.079	0.082	0.250*	**0.389****	−0.124	0.057	0.136
Predictors										
Anatomy			0.259*	0.200	0.102	0.108	0.158	0.099	0.232*	−0.173
Physiology				−0.015	0.236*	0.126	0.143	−0.013	0.031	0.045
Analysis confidence					0.279*	0.064	0.028	−0.074	−0.061	0.028
Learning confidence						0.**357****	0.150	−0.052	−0.056	0.081
Interest							0.233*	−0.120	0.150	−0.162
Exposure								−0.054	0.067	0.192
Figure-Ground									0.127	−0.234*
Visual-Closure										−0.196
Visual-Speed										

*$p < 0.05$ (two-tailed).
**$p < 0.001$ (two-tailed); correlations >0.30 in bold.
Measures—Notes:
Impairment identification: Swallowing impairments correctly identified (Post-training).
Anatomy: Anatomy test raw score (out of 8) (Pre-training).
Physiology: Physiology test raw score (out of 43) (Pre-training).
Analysis confidence: Confidence in VFSS analysis (rating from 0–100) (Pre-training).
Learning confidence: Confidence in ability to learn (rating from 0–100) (Pre-training).
Interest: Interest in VFSS (rating from 0–100) (Pre-training).
Exposure: Number of dysphagia clients seen previously during clinical placements (Pre-training).
Figure-Ground: DVTP-A Figure Ground subtest (Raw score) (Pre-training).
Visual-Closure: DVTP-A Visual-Closure subtest (Raw score) (Pre-training).
Visual-Speed: DVTP-A Visual-Motor Search subtest (Raw score) (Pre-training).
Abbreviations: DVTP-A, Developmental Test of Visual Perception–Adolescent and Adult; VFSS, Videofluoroscopic Swallowing Study.

TABLE 3 Stepwise regression analysis (Full model and backwards elimination model) with standardised β coefficient

	Outcome variable: swallowing impairments identified post-training	
Predictor variable	β coefficient, first equation	β coefficient, last equation
	R^2 0.285	R^2 0.219
	R^2 adj = 0.168	R^2 adj = 0.194
Anatomy	0.282	0.276
Physiology	0.114	
Analysis confidence	0.008	
Learning confidence	−0.107	
Interest	0.196	
Exposure	0.255	0.331
Figure-ground	−0.050	
Visual-closure	−0.018	
Visual-speed	0.178	

development: an understanding of anatomy and physiology, clinical experience in managing dysphagia, the university curriculum, confidence and visuo-perceptual skills (the ability to 'see' or 'track' the bolus (Edwards et al., 2019). The trainers identified these characteristics as being present in VFSS trainees who are 'successful'. Our present results have revealed that success in VFSS training for novice analysts was predicted by two key variables: clinical exposure to dysphagia cases (i.e., the number of clients with dysphagia seen on student placements) and the ability to identify anatomical landmarks on still radiographic films. These results concur with emerging trends in the existing literature as well as VFSS trainers' opinions (Edwards et al., 2019; Edwards et al., 2021). The findings are also consistent with Riojas' (2007) finding that academic experience predicted stronger performance.

The strongest predictors in this study were the participants' previous exposure to dysphagia cases and their ability to identify anatomical features on radiographic still images prior to training. Figure 1 visually represents the correlation matrix, with factors linked together according to their relationship.

When viewed as related groups of factors, a picture emerges that confirms the trainers' experience and opinions about the predictors of successful VFSS analytical skill development (Edwards et al., 2019). Individual learners may have strengths in the interrelated qualities of foundation anatomy and physiology knowledge, paired with visual processing skill, as clustered together to the left of the image. Other learners may bring clinical experience and a related interest in the area, as clustered together on the right. Both clusters are associated with a confidence in the ability to learn the skill of VFSS. Qualitative exploration of the impact of these factors on learners during the training process may uncover the nature of these relationships to further inform the development of training targets and practices.

Consistent with the radiology literature, clinical experience was related to the ability to detect disordered swallowing biomechanics (Waite et al., 2019). The exact nature of clinical experience that benefits the acquisition of VFSS analytical skill is difficult to determine. Previous clinical experience did not result in greater knowledge of anatomy or physiology: there was no relationship between clinical experience (the number of dysphagia cases seen) and pre-training knowledge of anatomy or physiology. The impact of exposure did not relate to the ability to analyse before training, but only to the ability to analyse after training. Learning the relationship between elements of knowledge can reduce the cognitive load in training (Blissett et al., 2012). The participants with greater and specific prior exposure to dysphagia cases may have had a better contextual base in which to embed the specific VFSS content and skills learned.

Destin and Oyserman (2010) found a relationship between student learning behaviour and their aspirations for employment. In their study, school-age children who aspired to adult employment that required a college education displayed more productive learning behaviours than those who expected to go to college but who aspired to adult work that was not associated with a higher education. Similarly, student placements have been shown to influence the eventual area of clinical practice for graduate speech pathologists (see for example, Speech Pathology Australia, 2018). For our university student participants, experience with people with dysphagia during placement, and the opportunity to experience an environment in which analysis skills contributed to workplace readiness, may have made the training more salient for the learners and encouraged productive learning behaviours.

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TABLE 4 Comparison of correlation of pre-training learner factors on outcomes pre- and post-training

Pre-training indicators*		Impairments identified pre-training	Impairments identified post-training		Paired *t* test change in correlation pre to post
Pre-training anatomy	Pearson correlation	0.076	0.306**	Paired *t* test	0.204
	Sig. (two-tailed)	0.525	0.009	*p* (two-tailed)	0.088
	N	73	71	*N*	71
Pre-training physiology	Pearson correlation	0.209	0.221	Paired *t* test	0.020
	Sig. (two-tailed)	0.078	0.064	*p* (two-tailed)	0.867
	N	72	71	*N*	70
Pre-training analysis confidence	Pearson correlation	0.033	0.079	Paired *t* test	0.039
	Sig. (two-tailed)	0.788	0.518	*p* (two-tailed)	0.752
	N	70	69	*N*	68
Pre-training learning confidence	Pearson correlation	−0.003	0.082	Paired *t* test	0.073
	Sig. (two-tailed)	0.977	0.500	*p* (two-tailed)	0.549
	N	71	70	*N*	69
Pre-training interest	Pearson correlation	0.085	0.250*	Paired *t* test	0.143
	Sig. (two-tailed)	0.483	0.037	*p* (two-tailed)	0.240
	N	71	70	*N*	69
Exposure	Pearson correlation	0.102	0.389**	Paired *t* test	0.248*
	Sig. (two-tailed)	0.392	0.001	*p* (two-tailed)	0.037
	N	73	72	*N*	71
Figure-ground	Pearson correlation	−0.019	−0.124	Paired *t* test	−0.087
	Sig. (two-tailed)	0.871	0.299	*p* (two-tailed)	0.470
	N	73	72	*N*	71
Visual-closure	Pearson correlation	0.073	0.057	Paired *t* test	−0.009
	Sig. (two-tailed)	0.537	0.637	*p* (two-tailed)	0.941
	N	73	72	*N*	71
Visual-speed	Pearson correlation	−0.015	0.136	Paired *t* test	0.138
	Sig. (two-tailed)	0.899	0.266	*p* (two-tailed)	0.263
	N	70	69	*N*	68

**Significant at the 0.01 level (two-tailed).
*Significant at the 0.05 level (two-tailed).
Measures—Notes:.
Impairment identification: Swallowing impairments correctly identified.
Anatomy: Anatomy test raw score (out of 8) (Pre-training).
Physiology: Physiology test raw score (out of 43) (Pre-training).
Analysis confidence: Confidence in VFSS analysis (rating from 0–100) (Pre-training).
Learning confidence: Confidence in ability to learn (rating from 0–100) (Pre-training).
Interest: Interest in VFSS (rating from 0–100) (Pre-training).
Exposure: Number of dysphagia clients seen previously during clinical placements (Pre-training).
Figure-Ground: DVTP-A Figure Ground subtest (Raw score) (Pre-training).
Visual-Closure: DVTP-A Visual-Closure subtest (Raw score) (Pre-training).
Visual-Speed: DVTP-A Visual-Motor Search subtest (Raw score) (Pre-training).
Abbreviations: DVTP-A, Developmental Test of Visual Perception–Adolescent and Adult; VFSS, Videofluoroscopic Swallowing Study.

The positive relationship between anatomy and analysis appears, at first, to be straightforward, but our methods have confounded this result. Being able to identify the structures involved in swallowing is a foundation skill for VFSS analysis and should provide a scaffold for the skills to be gained in training. The ability to identify landmark structures should provide a measure of a student's knowledge of the anatomy of the swallowing mechanism. In hindsight, the anatomy assessment should have used illustrated images or 3D models, rather than radiographic stills.

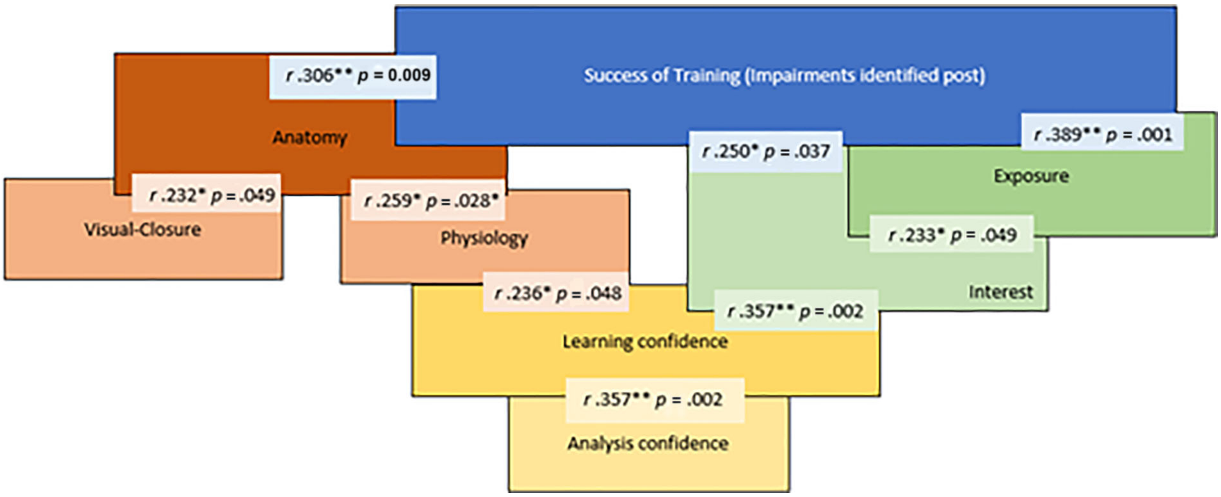

FIGURE 1 Visual representation of learner attributes that corresponded to success in training. [Colour figure can be viewed at wileyonlinelibrary.com]

By presenting radiographic images, the participants' perception of greyscale contrast and other visual processing skills potentially influenced the results, in addition to their knowledge of anatomy. Nordin et al. (2017) noted participants learning to conduct VFSS quantitative measures had the most difficulty with measuring airway closure duration. They hypothesised that there may be difficulty with more subtle greyscale differences in the airway, potentially affected also by poor screen resolution in the independent training environment.

There was no clear relationship between our study's visual processing results and training outcomes. However, our visual processing assessment was limited to the DVTP-A, as it was the tool available to the research team. The DVTP-A is particularly useful for identifying visual perceptual deficits in people with a range of neuropsychological impairments. However, it may not have been sensitive enough to identify variations in typical skills. It was also administered in a non-standardised way, in groups with the stimuli on screen, as it was beyond the resources of the study to complete individual assessments. It is possible that other visual processing skills and attributes, such as individual contrast sensitivity, differences in extrafoveal vision, visual reaction time, visual memory, and the ability to track a fast-moving object could influence speech pathologists' performance when rating a dynamic VFSS (Barten, 1999). The correlation between our measure of visual closure and the results of the anatomy pre-intervention strengthens the argument for reviewing visual perception with a more sensitive measure in future research.

Our model tested performance on accurate identification of impairments after a VFSS training intervention in a group of novice analysts with limited clinical experience. It is possible that as speech pathologists develop increasing competency, the factors that most strongly influence success may change because of experience and an increased level of difficulty of the target skills. When the correlations between the factors tested and the impairments identified in the pre- and post-assessments are compared side by side, it appears that the factors became more closely correlated with performance post-training than they were at the pretest, although this difference did not reach statistical significance. Eventual competence with higher levels of achievement may rely on some of these skills for more finely graded assessments. Our results are consistent with Nordin et al. (2017), who found that speech pathologists with greater clinical exposure had an initial benefit in developing speed in quantitative VFSS measures, but that this effect evened out after week 6 of training. As this was beginner-level training, the focus of this study was the influences on the ability to detect disordered swallowing biomechanics. Future research should assess the influence of swallowing physiology knowledge on the acquisition of the ability to comprehensively describe and appropriately manage dysphagia.

Future research

Our research confirms the expert opinions of the VFSS trainer participants in our 2019 study, who believed that clinical experience in dysphagia and the understanding of anatomy were characteristics of learners who succeeded in VFSS analytical training. These explanatory factors themselves were related to other factors hypothesised by the VFSS trainers as potential predictors of successful learners.

As the expectations of VFSS analysis increase, other factors may become more important. Our trainers suggested personal learning characteristics and preferences; cognitive attributes, including the ability to integrate and synthesise information, reach a decision, and communicate findings; and flexibility to adapt to more complexity as possible factors. The trainers noted that some learners were more comfortable in the busy VFSS environment than others and demonstrated the cognitive skills to cope with a fast and pressured environment. These factors were beyond the scope of the current study but are possible factors to include in future research exploring best practice in VFSS analytical training and competency development.

Limitations

There were a relatively small number of participants in this study, and they were relatively homogenous. The participants were from one country and studied at one university, which prevented these factors from confounding the analysis, but reduced the ability to confidently generalise our results to all novice learners. The learners' experience in their university is suggested as a potential influence on VFSS training and could usefully be explored in future research. Pretesting of the DVTP-A was not possible within the constraints of this study. As discussed, the DVTP-A visual perceptual test likely lacked sensitivity for a typical population. In a study of the DVTP-A's concurrent validity with other visual perceptual tests, Brown and colleagues (2009) found that the majority of their healthy adult participants scored highly, and there was a lack of variability in the scores. Additional key visual skills may not have been tested, such as the perception of speed and direction in moving images. A follow up assessment post-intervention would have strengthened the results by providing an assessment of the long-term influences on the retention of trained skills.

CONCLUSION

Our findings support the hypothesis that novice analysts vary in their ability to acquire new VFSS skills and that new speech pathologists benefit from clinical exposure and a strong grasp of anatomy with sufficient visual skill to see landmarks on still films prior to beginning training. VFSS trainers and potential analysts can use this information to understand the differences between learners, to respond in the training environment, and to better prepare for training.

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CONFLICT OF INTEREST STATEMENT

The authors report no declarations of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author, Ann Edwards. The data are not publicly available due to privacy and the requirements of ethical approval.

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APPENDIX

- Reduced hyolaryngeal excursion may result in…
- Reduced base of tongue strength may result in…
- Velopharyngeal incompetence may result in…
- Reduced tone of the lips and face may result in…
- Reduced tongue elevation may result in…
- Reduced floor of mouth strength may result in…
- Reduced tongue to velum seal may result in…
- Reduced pharyngeal wall constriction may result in…
- Mistimed activation of the pharyngeal wall constrictors may result in…
- Reduced epiglottic deflection may be associated with…
- Delayed initiation of the swallow may be associated with…