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Comparing Two Response Modes in a Mathematics Test for Learners in Foundation Phase with Severe Physical Disabilities: A South African Example

Juan Bornman[1], Dana K. Donohue[1,2], Nolette Maré[1] and Shakila Dada[1]

[1]Centre for Augmentative and Alternative Communication, University of Pretoria, South Africa
[2]Northern Arizona University, Arizona, USA

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ABSTRACT Research suggests that tests with non-modified response formats may be biased against learners with severe physical disabilities, with test scores reflecting the extent of learners' disabilities rather than their actual potential. This study aimed to compare the performance of learners with severe physical impairments on their mathematics scores using two different response modes. Forty-two learners from schools in the Gauteng province in South Africa were selected for the study. A cross-over within-groups design was used. Participants were randomly assigned to two groups; each learner participated in both conditions (oral response and eye gaze), but in the opposite order. The tests were repeated after a week when the alternative response mode was used. Participants' scores for the eye-gaze response mode were found to be significantly higher than their scores for the oral response mode. Implications for use in the classroom are discussed.

INTRODUCTION

All learners should be able to develop to their fullest potential. Moreover, every professional working in education should ensure that all learners are included, particularly those who are most vulnerable and most in need of assistance as far as achieving their educational goals are concerned (National Department of Education 2001; UNESCO Declaration on Education for All 2007). UNESCO (2007) contends that quality basic education should be accessible to all and enable all learners to express their knowledge and competencies effectively. Therefore, assessment should be done to support learning, rather than only attempt to credentialise or accredit learning (Nel 2015). Yet, accommodating learners with disabilities in the classroom, including those with physical disabilities, poses many challenges, for example, how to provide testing accommodations for these learners in a way that reflects their knowledge or skills (Casey et al. 2007; Fuchs et al. 2000; Sireci et al. 2005). Teachers have to provide "outcome-neutral" accommodations. Such accommodations allow learners with disabilities fair and equal access to tests without being either advantaged or disadvantaged by their impairments and/or the assessment methods that are used (Lovett and Lewandowski 2014). A crucial element in education, therefore, lies in the consistency between teaching and assessment (DBE 2014; UNESCO 2012).

An assessment approach and plan is required that is flexible enough to accommodate a range of different learner needs (DoE 2011; UNESCO 2000). Curriculum-based assessments should ideally be integrated into teaching and learning, and should aim to enhance learners' individual growth and development, as well as facilitate and monitor their learning (Engelbrecht 2013).

Test accommodations refer to adjustments in the way that tests are administered and presented, or to changes in how learners should respond to tests. In other words, learners need to be allowed a different way to show teachers what they know (Bouwer 2016; National Department of Education 2001). Test accommodations can include modifications or alterations to (i) the presentation format (for example verbal encouragement, test directions, assistance during the test); (ii) the response format (for example the use of aids, different response modes) or (iii) the timing/scheduling of the test and the setting (Thurlow et al. 2003; Venter 2015). Teachers find the assessment of learners with

Address for correspondence:
Juan Bornman
Centre for Augmentative and Alternative Communication
University of Pretoria
0002 Pretoria South Africa
Telephone: +27 12 420 2001
E-mail: juan.bornman@up.ca.za

severe physical disabilities challenging as the traditional formats (oral and/or written) are often inaccessible for learners with severe physical disabilities due to the nature and/or severity of their disability (Casey et al. 2007). Most schools simply offer test accommodations such as additional time to complete a test, a private room in which to take the test, or a reader to read out the test items (Lewandowski et al. 2013). Multiple-choice tests with a bubble-sheet response format or the circling of responses in a test booklet (to a lesser degree) are also sometimes used, seeing that they have been officially approved by education departments in the USA and in other countries (Potter et al. 2015). However, none of these test accommodations are really suited to the needs of learners with severe physical disabilities, as these accommodations are suited to learners with learning disabilities, dyslexia and ADHD and do not address physical requirements (for example, the fine motor skills required to hold a pen).

Learners who experience difficulty in completing a test in its typical format (usually pen-and-paper-based) will need an accommodation that ensures equal access. For example, on a test of mathematics, learners with severe physical disability may be unable to write or speak their response to the questions posed and thus they will require an alternative response format (for example eye-gaze). Limited research evidence exists to support the validity of test accommodations for learners with severe physical disabilities, as few studies have been conducted to investigate whether changes in response modes have an impact on learner performance (Casey et al. 2007) and the extant research often shows conflicting results (Fuchs et al. 2000; Lovett and Lewandowski 2014; Sireci et al. 2005).

Although several studies have examined the effects of test accommodations such as extra time to complete the test (for example, Sireci et al. 2005 ; Venter 2015), few studies have examined the validity of using different response modes in tests. For instance, Wagner (1994) used yes/no responses during assessment on the standardised form of the Peabody Picture Vocabulary Test-Revised (Dunn and Dunn 1981). The PPVT-R is a test of receptive language, and it was administered to 25 adults who exhibited a range of physical and intellectual impairments. Results showed that the binary format accurately assessed the participant's receptive language abilities. This implies that Wagner's modified response format provided a practical alternative to the standard administration (asking the participant to point to a picture from a choice of four) in the case of people with severe physical and communication disabilities. In their study, Brown and McMullen (1982) compared test performance by using two different response formats during a test of intellectual ability: firstly the traditional oral response mode, and secondly the eye-gaze mode. Eye gaze is a primary motor task through which a learner can demonstrate choices by looking at the specific options and then fixating his/her gaze on the desired selection (Majaranta and Bates 2009). Results showed that learners without physical disabilities displayed no differences on the two methods of response, whereas the learners with physical disabilities significantly improved their scores when using the eye-gaze method of response (Brown and McMullen 1982). These findings suggest that tests with non-modified response formats may reflect the extent of a person's disability rather than actual potential. Casey et al. (2007) also compared the oral response mode and the eye-gaze mode, albeit in a test of phonological awareness with neurotypical learners, and reported no significant differences in test scores. These studies all used a binary response mode, which may be unsatisfactory as learners have a 50 percent chance of providing the correct response (Casey et al. 2007). However, earlier research suggests that providing learners with two choices as a response format is generally an adequate and accepted test accommodation (Haladyna and Downing 1993). Keeping the potential pitfalls related to binary response modes in mind, Pufpaff (2011) then explored the effects of three response modes on phonological sensitivity tests, also for neurotypical learners, namely (i) oral response mode, (ii) oral response mode combined with pictures, and (iii) pointing as a response mode. The results showed no statistically significant difference between these three response modes. Together, the findings from the above empirical studies suggest that as a response format, eye gaze does not appear to alter performance for learners who do not need test accommodations (that is, neurotypical learners), but significantly improves the scores of those who do (that is, learners with disabilities).

An eye-gaze response mode that provides learners with severe physical disabilities with several potential responses from which they need to choose the correct answer (for example, a mathematics test with one correct response from four potential choices) may be a practical test accommodation for teachers in the classroom context. Therefore, the appropriateness and validity of the eye-gaze mode of response as a test accommodation for learners with severe physical disabilities should be examined in more detail. Research needs to ascertain whether it is a valid response mode that provides neither an unfair advantage nor disadvantage to learners with severe physical disability during testing. Using a mathematics test that compares the oral response format with the eye-gaze response format in learners with severe physical disability is applicable to the learners' educational level and environment. In summary, the use of eye gaze as a test accommodation may be appropriate when more conventional response modes (oral or written response modes) are not accessible to the learner with severe physical disability.

Objectives

The purpose of this study was to compare the efficacy of two different response modes, namely an eye-gaze response mode and the oral response mode, for a test of mathematics for learners with severe physical disability. It was hypothesised that learners with severe physical disability would obtain significantly higher test scores in the eye-gaze response mode than in the oral response mode.

MATERIALS AND METHODS

A crossover within-groups design was employed for this study, as is shown in Figure 1.

Each participant received two mathematics tests to complete, and they were asked to use both response modes. Participants were assigned to groups: Group 1 used the oral response mode first, followed by the eye-gaze response mode a week later, while Group 2 answered the tests in the opposite order. Groups were selected using the following method: All participants completed a mathematics test in class, after which their scores were ranked from highest to lowest. The learner with the highest score was assigned to Group 1; the one with the second highest score to Group 2; the next one again to Group 1, and so on, until all the participants were placed in the two groups. Thus, the participants were sorted into the two groups in descending order on the basis of their pre-test mathematics scores. This was done in order to ensure that the two groups were equivalent in terms of their performance before commencing the study.

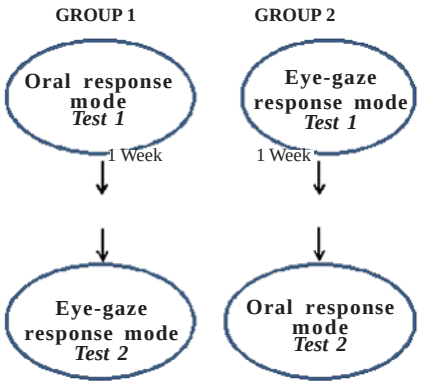

Fig. 1. Cross-over within group design.
Source: Authors

Participants

The participants were recruited from government-run special schools for learners with disabilities in an urban community in South Africa. Despite South Africa's inclusive education policy, learners with disabilities are still taught in separate, special schools. These schools were therefore targeted because a much higher proportion of learners with severe physical disabilities attend special schools compared to mainstream schools (Donohue and Bornman 2014). Five principals at special schools for learners with severe physical disabilities consented to participate. Information letters explaining the purpose of the study were sent to the parents of all the Grade 3 learners via their teachers. If the parents returned a signed informed consent letter to the teacher, the learners were recruited for participation. Each learner was asked to complete an assent form by using green (yes) or red (no) stickers to answer the following three questions: (i) Do you understand what you have to do? (ii) Do you want to take part in the study? (iii) May I take a video while we do this activity? All 42 potential participants assented. The learners – 27 boys and 15 girls – were all in Grade 3

and their ages ranged from 8 years 2 months to 11 years 9 months (M = 10.19 years). A physiotherapist classified the severity of their physical impairment by using the Gross Motor Classification System, Expanded and Revised scale (Palisano et al. 2007). The GMFCS E+R scale is based on self-initiated movement, with the emphasis on sitting, transferring from one position to another, and mobility. Levels are based on functional limitations, need for devices and (to a lesser extent) the quality of movement. Level I indicates that a person can walk without any limitations, while Level V means that he/she must be transported in a wheelchair. All participants in this study functioned at Level V.

Materials

An E-tran frame was used to capture the learners' eye-gaze responses as it is an effective way of using eye gaze to indicate a choice. The E-tran used in this study was a square frame measuring 35cm by 35cm. The number symbols displayed on the E-tran measured 8.5cm by 8.5cm (and contained the numbers 16, 20, 24 and 30, which were all possible answers to the mathematics test questions). The number symbols were attached to the four corners of the E-tran, and back-to-back on the frame in order for the learner and researcher (a qualified speech-language therapist) to both see them (see Fig. 2).

The frame was placed on a table between the researcher and the learner at eye level, and the learner indicated his/her answer to the mathematics question by looking at one of the specific number symbols that were placed in a specific location. The researcher would then identify the intended answer by judging the focal point of the learner's eyes, and confirmed the learner's choice by saying, for example, "*You are looking at 20*" (Bornman 2011). Using only four locations on the E-tran facilitated the correct and unmistakeable identification of the answers. A test of adding and multiplication with 15 items was compiled from class work as prescribed by the ALL-IN-ONE Integrated Learning Programmes (Best Books Panel 2003). A small review panel (consisting of mathematical teachers and the head of department for the Foundation Phase at a special school) met to discuss the proposed test, and they confirmed that it was at the appropriate level for Grade 3 learners. The maximum score was 15 (1 point allocated for each correct answer for each of the 15 items) with 0 being the lowest. Each participant's responses were recorded on a data response sheet that

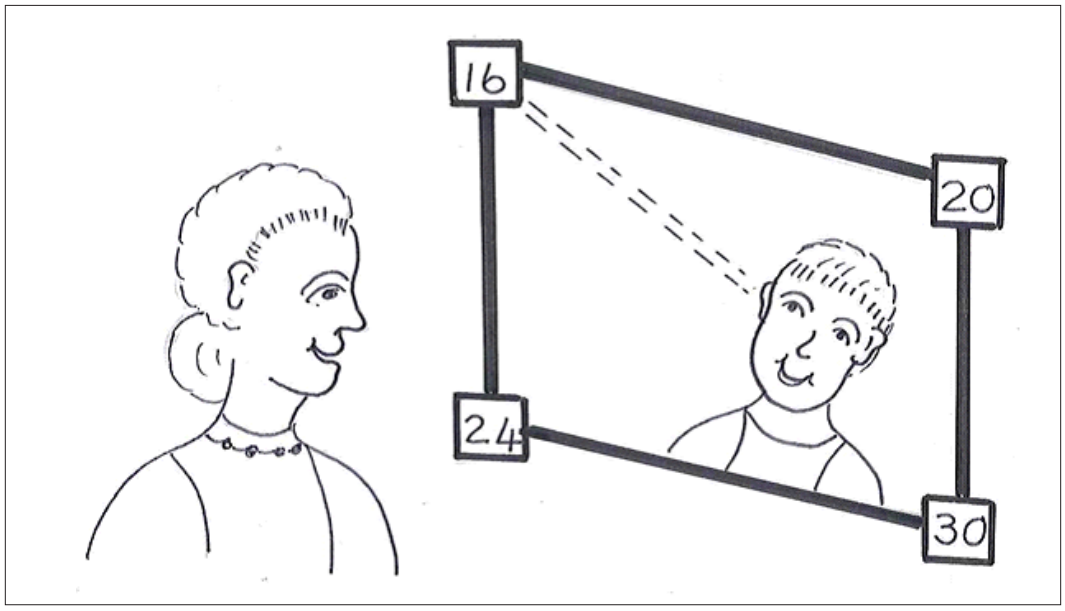

Fig. 2. Picture of the E-tran device used in this study
Source: Authors

captured his /her performance for both the oral response format and the eye-gaze response format. All answers were then evaluated as being either correct or incorrect, and the scores for the two response modes were compared.

Procedures

Permission to conduct the study was obtained from the Ethics Committee at the relevant tertiary institution. Formal permission was obtained from the Gauteng Department of Education. The principals of five special schools for learners with physical disabilities in three school districts (two in Pretoria, two in Johannesburg, and one in Ekhuruleni) in the Gauteng province of South Africa were contacted telephonically, informed of the aim and nature of the study, and asked for permission to conduct the study. All consented. A pilot study was conducted to identify and eliminate all potential difficulties regarding the material and the procedure, for example, presenting the mathematics both orally and visually, shortening the instructions of how to use the E-Tran as participants easily understood what was expected of them and increasing the time allocated per participant as transitioning from the classroom to the testing room differed depending on the physical requirements of the children (Maré 2010). Dates and times for data collection were discussed with the principals and teachers, which resulted in minimal disruption of the classroom schedule. All participants were tested individually by the researcher in a classroom reserved for the study and given the same instructions. Three practice items were given, followed by corrective feedback if necessary. Thereafter the actual test was administered. No feedback was given during the test itself and each of the 15 test items was asked only once, simulating the typical test atmosphere to which the learners were accustomed. The first time, Group 1 answered the test questions using the oral response mode, while Group 2 answered the questions using the eye-gaze response mode, as shown in Figure 1. The same test was repeated a week later. The second time, however, the order of digits in the mathematical calculations was reversed (for example, 12+4=__ changed to 4+12= __) to ensure that participants would not recall their responses from the previous week, which would then become a threat to internal validity (Aguinis and Edwards 2014). The order of response modes was reversed when the test was administered a week later, thus Group 1 then completed the test using the eye-gaze response mode and Group 2 used the oral response mode.

RESULTS

Data screening and analyses were conducted using the Statistical Package for the Social Sciences 17.0 (SPSS). The data was first checked for accuracy of data entry, missing data and outliers. Participants were each given two scores; one score was the sum of their correct oral responses and the other score was the sum of their correct eye-gaze responses. The mean score for participants' oral response mode was $M = 10.12$, $SD = 4.00$, while the mean score for participants' responses when they used the eye-gaze response mode was $M = 11.33$, $SD = 3.40$. The maximum correct score was 15, and the minimum was 0. These scores were compared using a paired sample t-test to determine whether the scores were significantly different. A statistically significant difference was found, $(41) = -3.97$, $p < .01$, $d = .61$, suggesting that participants scored significantly higher when they used the eye-gaze response mode than the oral response mode.

DISCUSSION

Teachers have a need for practical test accommodations for learners with severe physical disabilities. These should move beyond allowing learners extra time to complete the test, a private room to take the test, a reader to read the test items to the learner and/or a multiple-choice format that requires responding on a separate answer sheet (Bouwer 2016; Lewandowski et al. 2013; Potter et al. 2015). The purpose of this study was to explore the use of an alternative response mode, namely eye gaze as a potential test accommodation with practical appeal in the classroom for teachers who teach learners with severe physical disabilities. A mathematics test was selected as it requires a single correct answer from the learner for each item. All participants were provided with both response modes (in an alternating pattern) to ascertain whether the different response modes altered the learners' performance.

The results of the current study showed that participants scored significantly higher when given the opportunity to respond by means of eye gaze than by means of oral responses. This finding is similar to that of the Brown and McMullen (1982) study, which also found that the scores of learners with physical impairments improved significantly in a test of intellectual ability when using the eye-gaze method of response. Both these studies therefore indicate that learners with severe physical disabilities improve their test scores when responding by means of eye gaze.

There are several explanations for this finding. Goossens (1989) proposed that eye gaze is a natural response mode and precedes the verbal response mode; eye gaze also may be easier, quicker, and more effective than other testing accommodations, especially for people with physical disabilities (Donegan et al. 2009). Casey et al. (2007) suggested that under cognitively demanding conditions (for example, test taking), learners revert to a previous and more immature level of response mode in order to accurately respond to questions. Hence, they suggested that the eye-gaze method might be more immature, but easier to use.

On the other hand, the provision of four potential answers on the E-tran (whereas no possible answers were provided for the oral responses) may have artificially boosted participants' scores when they used the eye-gaze method. The four-option multiple-choice questions ensured a lower probability of inadvertently guessing correctly than if only a binary option (for example, yes/no) was given. However, research suggests that even a binary format is sufficient for most ability and achievement tests (Haladyna and Downing 1993).

CONCLUSION

This study emerged from a concern about the limited test accommodations available for learners with severe physical disabilities in the classroom context. Although accommodations are encouraged for learners with disability little research has been conducted to verify different test accommodations, in particular response modes available for learners with severe physical difficulties. The study therefore sought to investigate the possibilities of using eye gaze as a response mode when more conventional response modes (for example, oral and/or written modes) are not accessible to learners with severe physical disabilities and when binary response modes are deemed too easy. The findings of this research suggested that the eye-gaze response mode improved the participants' mathematical test scores – which may have implications in terms of test accommodations. Teachers should be equipped with the necessary skills to provide test accommodations that will allow all learners, even those with severe physical disabilities, to demonstrate what they know. Teachers thus need to know how to modify regular test conditions to allow learners with disability access to the question, not to the answer – for instance by using a different response mode. This has implications for teacher training curricula as newly qualified teachers need to understand how to adapt tests for learners with physical disabilities in terms of response modes. By providing support and the necessary flexibility to accommodate all learners, learning can take place in the classroom.

RECOMMENDATIONS FOR FURTHER RESEARCH

Several changes can be made to the eye-gaze response mode. For example, providing a different set of possible answers to each question could be an option. However, this option can be time consuming for teacher who has a full class of learners, and it may have a negative impact on practicality. Speech-language pathologists may support teachers in this regard.

Another change can be to provide the same set of possible answers for both the oral response and eye-gaze response mode. However, this change may affect the test validity, making a within-groups design not possible. An alternative option would be to find two different groups to participate in the study, to allow each group only one condition, and then to compare their scores. A much larger sample would be needed for this independent-groups design, however, and such a sample may be difficult to find for atypical populations (for example, learners with severe physical disabilities).

A further change that could be made to the eye-gaze response mode would be to include different questions that are determined to be equivalent in difficulty for both conditions. Determining this equivalence can sometimes be

quite challenging. Although at this point there is no easy way to ensure test validity of the eye-gaze response mode as a test accommodation, the use of eye gaze as a response mode has the potential to provide an opportunity for learners with severe physical disabilities to participate in class tests. While not perfect, eye gaze may be an option when no other response modes are available for learners with severe physical disability. This would help greatly to address UNESCO's Education for All (2000) point, namely that all learners should have access to the standard of assessment that is best suited to their needs. Current inequitable and exclusionary practices associated with assessment can thus be addressed to ensure that all learners are eligible to be supported within an integrated education system.

STUDY LIMITATIONS

The results of this study are troubled by several limitations. The use of a fixed set of possible answers on the E-tran for the eye-gaze response mode can be seen as a limitation that may have affected the validity of answers. Future studies should consider changing the set of possible answers with each question. Even though time consuming, it would provide valuable information on the difference in scores on the oral versus the eye-gaze response modes and may help to further confirm the validity (or lack of validity) of this test accommodation.

Another limitation pertains to the relatively small size of the sample of participants. It should, however, be acknowledged that garnering large samples of atypical populations (for example, learners with severe physical disabilities) can be difficult. Additionally, the age group was between 8 and 11 years of age, and consisted of learners in Grade 3. It might be of value for future research to include different age groups as well as different grades to explore whether the eye-gaze method is appropriate for learners across the academic spectrum. It would also be of value to extend the number of potential answers on the E-tran used in the mathematics test from four to six, or even to eight possible answers, depending on the age and ability of the learners.

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