JORSEN
Journal of Research in Special Educational Needs
nasen
Helping Everyone Achieve
An International Peer Reviewed Journal

Journal of Research in Special Educational Needs · Volume •• · Number •• · 2013 ••–••
doi: 10.1111/1471-3802.12039

Single-subject designs in special education: advantages and limitations

Ghaleb H. Alnahdi

Special Education Department, College of Education, Salman bin Abdulaziz University, Saudi Arabia

Key words: Single subject, single case, SCDs, research designs, evidence-based practice.

Single-subject designs provide the special education field with an alternative to group designs. The purpose of this paper is to introduce the topic of single-subject designs by providing an overview of the relevant literature and a discussion of the major issues and applications of these designs in the field of special education. This paper is divided into four main sections: (1) characteristics of single-subject designs; (2) types of single-subject designs; (3) advantages of single-subject designs; and (4) issues and concerns regarding single-subject designs. It was concluded that a minimum of three measurements in each phase is typically required until there is a clear pattern. Flexibility and cost-effectiveness are among the main advantages of these designs. External validity and generalisability are the main concerns. However, meta-analytic studies can enhance the generalisability of single-subject designs findings within similar context. Conclusions and recommendations to improve these designs are discussed.

Introduction

Science should guide special education practices (Odom, Brantlinger and Gersten et al., 2005). However, it can be very difficult to conduct scientific research in the field of special education due to the presence of much higher variability among persons with disabilities than among individuals who lack disabilities (Odom et al., 2005). The heterogeneous characteristics of individuals with disabilities render it challenging, even with sample randomisation, to assemble equivalent groups to compare and study (Parker, Grimmett and Summers, 2008).

Single-subject designs provide the special education field with an alternative to group designs (Engel and Schutt, 2008) and constitute the most feasible types of experimental designs for individuals with disabilities (Parker et al., 2008). Notably, single-subject designs were originally derived from the medical field and employed in special education studies because many of the early service providers for individuals with disabilities were physicians (Odom et al., 2005). Single-subject designs allow educators to compare each participant's performance with his/her other performances across various settings (Tankersley, Harjusola-Webb and Landrum, 2008). Thus, this method allows educators to evaluate the effectiveness of many different treatments on their students and make decisions about which of these treatments are effective.

Single-subject designs have been widely employed since the 1960s. Over the course of the past 50 years, the cumulative knowledge regarding the conduct of these studies has greatly increased, and the ways in which reports are derived from these studies have improved (Wolery, Dunlap and Ledford, 2011). The role of single-subject designs in systematic policies and procedures for promoting evidence-based practices in education has been emphasised (Horner, Carr and Halle et al., 2005). Special education is a field that focuses on the individual student as the unit of concern and stresses the importance of active intervention for increasing desirable behaviour or decreasing undesirable behaviours; special education is also a problem-solving discipline in which the need for constant studies in applied settings is crucial (Horner et al., 2005).

According to Horner et al. (2005), single-subject research is an experimental design in which causal and functional relationships can be identified between independent and dependent variables. The functional relationship is demonstrated when change in the independent variable is followed by change in the dependent variable (Horner, Swaminathan and Sugai et al., 2012); in another word, change in the independent variable related to change in the dependent variable. But in the casual relationship, there is a need to confirm that change in the independent variable causes the change in the dependent variable (Crano and Brewer, 2002).

Typically, in this type of research designs, behaviours or performances from two different phases of an experiment are compared; in particular, behaviours or performances before an intervention are contrasted with behaviours or performances that occur during or after the intervention of interest. Either one participant or multiple participants (with a typical range of three to eight participants) are in each single-subject research study (Horner et al., 2005).

The significance of this paper is driven by the facts that single-subject designs are commonly used in the special

education arena (Maggin, O'Keeffe and Johnson, 2011) and provide the special education field with an alternative to group designs (Engel and Schutt, 2008). Therefore, 'it is important that educators and educational professionals understand the characteristics of single-subject research methodologies and how those characteristics allow conclusions to be drawn about [the] effectiveness of practices' (Tankersley et al., 2008, p. 83).

This paper provides an introduction to single-subject designs through an overview of the related literature and a discussion of the major issues and applications of these designs in the special education field. The specific objectives of this paper are (1) to present the methodological characteristics of single-subject research designs, (2) to present the types of single-subject research design that can be utilised in special education, and (3) to discuss the advantages and the limitations of using single-subject designs compared with other research designs.

Methodology

To discover articles that discussed the use of single-subject design in special education, the researcher reviewed articles that were listed in the Education Resources Information Center (ERIC), EBSCOhost and Academic Research Complete databases in February 2012 under one or more of the following headings: 'single-subject', 'single subject designs', 'single-subject' with 'special education' and 'single case' with 'special education'. The articles that were revealed through this search were initially limited to documents that were published during or after the year 2000 due to the time constraints that were applicable with respect to this paper. However, at the researcher's discretion, several articles that were published before 2000 were added to the pool of examined documents. After reading the abstract of each article that appeared to be relevant to the topic of this paper, the researcher decided whether to conduct an in-depth examination of the article in question. In addition, the researcher searched for 'single-subject research or design' in the ALICE system of the Ohio University library for books that discussed single-subject designs in educational studies. In summary, two criteria were used to select studies for this review: (1) the discussion of any type of single-subject design, and (2) a special education context.

Single-subject design characteristics

It is essential for educators to understand the characteristics of single-subject designs. This understanding will allow these educators to reach appropriate conclusions regarding the effectiveness of certain interventions or practices (Tankersley et al., 2008). Horner et al. (2005) argued that single-subject designs are important and powerful methods for improving the special education practices that are used for students with disabilities and their families.

Single-subject designs often study more than a single person; the term 'single subject' simply refers to the fact that each participant in a single-subject study serves as his/her own control (Wolery et al., 2011, p. 103). Typically, in these types of experiments, data are collected on several different occasions for each participant under two (A-B) or more conditions, and the data patterns for each participant are then analysed across the examined conditions (Wolery et al., 2011).

Horner et al. (2005) listed several characteristics that make single-subject designs appropriate for the needs of the special education field. First, single-subject designs are focused on individual level and do not require populations that fulfil certain conditions, such as the presence of a normal distribution. Second, single-subject designs may provide a practical methodology for examining behavioural or educational interventions. Third, single-subject designs can be implemented under typical educational conditions, avoiding the frequent concern that experiments may be performed in contexts that differ from real educational settings. Fourth, single-subject designs are cost-effective methodologies for testing behavioural or educational interventions.

McMillan (2004) has summarised five important characteristics of single-subject designs that demonstrate the satisfactory nature of these designs.

1. **Reliable measurement:** Single-subject designs typically involve multiple measures of behaviour; therefore, it is important for the instrumentation to be consistent and reliable. The standardisation of data collection conditions, such as time of day, location and the observer's training, improves measurement reliability.
2. **Repeated measurement:** In single-subject designs, the same behaviour is measured repeatedly; this feature differentiates single-subject methodologies from most experimental designs. In these repeated measurements, the researcher looks for clear patterns or consistencies in a subject's behaviour over time.
3. **Description of conditions:** In single-subject designs, a comprehensive description of the study's measurement and treatment conditions are essential to enhance the study's validity.
4. **Baseline and treatment conditions:** Single-subject designs involve at least two conditions, typically, the baseline condition and the treatment condition. The baseline represents a period of time during which the dependent variable is recorded without any intervention; behaviours under this condition provide a frame of reference for comparisons to future behaviours that may occur during the intervention period. The treatment condition, which is typically symbolised by B, is a period of time during which a treatment or intervention is introduced and the dependent variable continues to be recorded. The baseline phase and the treatment phase must continue until a clear pattern for the dependent variable has emerged.
5. **Single-variable rule:** In single-subject research designs, one variable should be introduced to the study participants after the baseline phase and studied in the intervention phase. If two variables are introduced in the intervention phase, these variables may interact,

and it will be necessary to examine the interaction between these two variables.

The dependent and independent variables in single-subject designs

Horner et al. (2005) indicated that the dependent variable in single-subject designs should be definable and measurable. These researchers identified four features that the dependent variable is required to satisfy. First, the dependent variable should be operationally defined to allow for (1) valid and reliable assessment and (2) assessment replication. Second, the measurement process should occur continually both within and across the intervention phases of a study to identify the performance patterns for each participant prior to the intervention and permit each participant's performance patterns to be compared across the experimental conditions. Third, the performance data on the dependent variable should be assessed for reliability during the research by inter-observer agreement (e.g., the proportion of agreement among observers with respect to observational units) or an equivalent metric. Fourth, the dependent variables should be selected based on their social significance and their importance to the experimental participants (Horner et al., 2005).

The independent variable in single-subject designs is the intervention or practice that is being assessed. According to Horner et al. (2005), the independent variable should 'allow both [the] valid interpretation of results and [the] accurate replication of the procedures' (Horner et al., 2005, p. 167).

Horner et al. (2005) observed that the implementation of an independent variable in single-subject designs over time raised a concern that is known as the *fidelity of independent variable implementation*. These researchers added that the 'documentation of [the] adequate implementation fidelity of [the] independent variable is expected either through continuous direct measurement or [through] an equivalent' (p. 168).

Horner et al. (2005) emphasised several characteristics of the dependent variable that enhance the quality of single-subject designs. In particular, the dependent variable should be (1) described with sufficient specificity to allow for the replication of the study; (2) assessed in a manner that allows a quantifiable index to be obtained; (3) evaluated for validity; and (4) measured over time. Horner et al. (2005) also stressed several characteristics of the independent variable that enhance the quality of single-subject designs. In particular, the independent variable should be (1) described with sufficient specificity to allow for the replication of the study; (2) 'systematically manipulated and under the control of the experimenter' (p.174); and (3) measured in a manner that allows its fidelity of implementation to be assessed.

Summary

Originally, 'single subject' referred to 'the fact that each participant serves as his/her own control' (Wolery et al., 2011, p. 103). In single-subject experiments, data are documented repeatedly for each participant in two or more phases (the baseline phase and the intervention phase), and the data patterns are compared across these phases to allow for the effectiveness of the examined intervention to be examined for each participant (Wolery et al., 2011).

Horner et al. (2005) argued that single-subject designs are important and powerful methods for improving practices in the special education field for students with disabilities and their families. Single-subject designs provide methods of examining interventions for exceptional populations, such as special education students. In addition, single-subject designs may provide evidence-based results that could improve special education practices. Because single-subject designs can readily be adapted to different situations and educational settings, these designs are cost-effective.

To increase the quality of single-subject research designs, certain important characteristics should be present in these designs, such as (1) measurements that are reliable and consistent, (2) the ability to repeat the measurement as often as necessary, (3) sufficiently detailed descriptions of the measurement and treatment conditions, (4) at least one baseline and one treatment phase, and (5) changes in only one variable between the baseline and treatment conditions (McMillan, 2004). In short, single-subject designs repeatedly collect data about each participant across two or more phases, allowing for the variability in the data patterns for each participant across these phases to be examined (Wolery et al., 2011).

Types of single-subject designs

Ideally, researchers using single-subject designs manipulate only one variable to evaluate the functional relationship between the independent and dependent variables of a study (Hammond and Gast, 2010). However, there are different types of single-subject research designs, each of which possesses its own specific applications. These differing designs are described in the following paragraphs.

Basic designs (A-B)

An A-B design, where A refers to the baseline phase and B to the treatment phase, is the most basic single-subject research design. This type of experiment only allows for correlational conclusions to be obtained. In this design, the dependent variable's performance is recorded in the baseline phase (A) and the intervention phase (B), and the performances during these two phases are then compared (Engel and Schutt, 2008; Hammond and Gast, 2010) (see Figure 1). This design is not valid against the maturation threat; for example, when participants get older and improvement in performance is recorded, how this design can prove that this improvement is due to the intervention and not because the participants get older.

Withdrawal designs

Reversal or withdrawal designs (Hitchcock, Nastasi and Summerville, 2010) involve the systematic introduction and removal of the independent variable across the baseline and the intervention conditions (A-B; A-B-A; A-B-A-B;

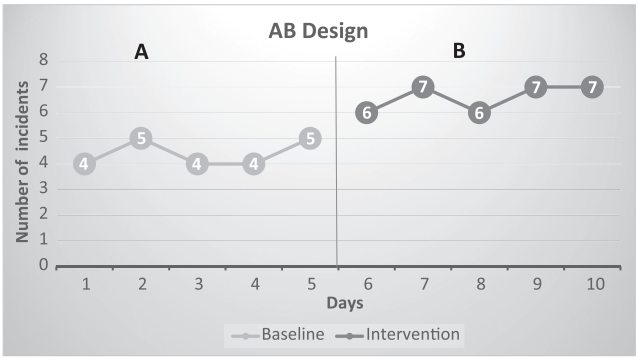
B-A-B). In withdrawal designs, the independent variable is only introduced to influence a target behaviour during the intervention phases, and this independent variable is not present during the baseline phases of the experiment (Hammond and Gast, 2010) (see Figure 2).

Withdrawal designs allow for the reliable assessment of treatment effectiveness through the introduction and withdrawal of the treatment during the experiment. However, these designs cannot be used to address situations in which there are ethical concerns regarding the withdrawal of treatment or scenarios that involve irreversible treatment effects (Gast, 2009).

Multi-treatment designs

Hammond and Gast (2010) state that in multi-treatment designs, a behaviour must be reversible. This condition causes multi-treatment designs to be similar to withdrawal/reversal designs. Multi-treatment designs are used to compare the effects of multiple methods of interventions on the baseline condition or to compare these types of interventions with each other (e.g., A-B-A-C-A-C or A-B-A-C-B-C-B) (Hammond and Gast, 2010).

Figure 1: A-B Design



Multiple baseline designs

In withdrawal designs, the individual serves as the control for the effectiveness of the treatment. Because multiple baseline designs (see Figure 3) add additional subjects, settings, or target problems to the experiment, these designs can provide a solution to the ethical problems that result from either the early withdrawal of treatment in an experiment or the existence of irreversible target behaviours in certain studies (Engel and Schutt, 2008). Multiple baseline designs can be implemented in the following five ways:

1. **Concurrent multiple baseline designs,** which involve the concurrent implementation of a number of basic A-B designs for more than two cases.
2. **Non-concurrent multiple baseline designs,** which involve different lengths of time in the baseline phase for different experimental subjects.
3. **Across subjects designs,** which involve each experimental subject receiving the same intervention (in a sequential fashion) to address the same target problem.
4. **Across target problems designs,** which involve introducing the same treatment to a single participant in the context of different but related problems.
5. **Across different settings designs,** which involve applying the same intervention to a single participant in different settings (Engel and Schutt, 2008).

Multiple probe designs

These designs are similar to multiple baseline designs; however, in contrast to multiple baseline designs, the baseline data in multiple probe designs are collected intermittently (Hammond and Gast, 2010).

In summary, there is no particular consensus regarding the different types of single-subject research design in the literature, particularly not with respect to the categorisation of these designs. Certain researchers consider the A-B basic design to be a withdrawal design, although there is no

Figure 2: A-B-A-B Design

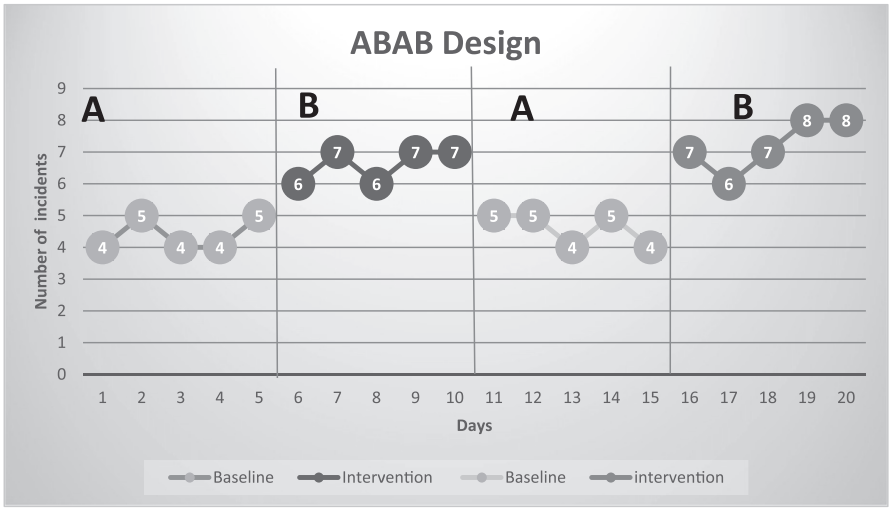
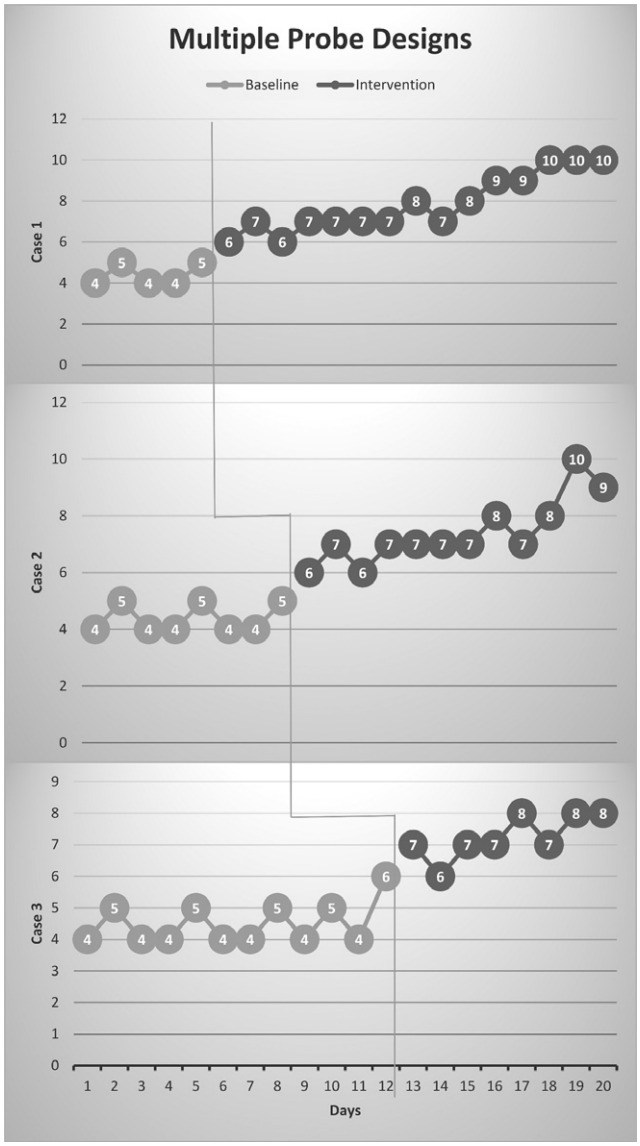


Figure 3: Multiple Baseline Design



withdrawal of the intervention in this basic design. Moreover, other researchers regard the withdrawal design and the reversal design as interchangeable, because both of these designs can feature interventions that precede the baseline conditions. After reviewing the body of literature with respect to types of single-subject research designs, the researcher in the current study used the following system of categorisation: (1) basic A-B designs, (2) withdrawal designs, (3) multiple baseline designs and (4) multiple probe designs.

Engel and Schutt (2008) identified five types of multiple baseline designs: concurrent multiple baseline designs, non-concurrent multiple baseline designs, across subjects designs, across target problems designs and across different settings designs.

The main purpose of a particular study should guide a researcher towards choosing the single-subject research design that most effectively facilitates the accomplishment of his/her goal. Researchers can sometimes find themselves in situations that necessitate the choice of a multiple baseline design to address ethical concerns regarding the withdrawal of treatment. Therefore, researchers should decide which type of single-subject research design would be most appropriate for their studies based on their study goals, the context of their studies, the study participants and other relevant circumstances. Also, it is possible to combine different designs together.

Conducting single-subject research

To utilise single-subject designs in special education or any other educational field, the target behaviour or skill to be treated or enhanced in the study must first be specified. For illustrative purposes, let us assume that a researcher wishes to minimise the number of times that a student takes his/her classmates' belongings without permission. This target behaviour is the dependent variable in the single-subject design, and the researcher seeks to examine the effects of a particular intervention strategy or method with respect to decreasing this behaviour. The intervention method or treatment is the independent variable in this design.

After specifying a dependent and an independent variable for the study, the number of times that the student takes his/her classmates' belongings without permission must be recorded for a number of days. These recorded data form the baseline for the study and are collected prior to the occurrence of any type of intervention. In the next phase of the study, an intervention should be implemented for the student over the course of a number of days (or sessions), and the student's behaviour should be recorded during this time. This second phase (B) is the intervention phase. These two phases can be repeated multiple times. Finally, the baseline data (the number of times that the undesirable behaviour occurred) should be compared with the data that were recorded during the intervention phase to examine the effect of the intervention (the independent variable) on the behaviour of interest (the dependent variable). In an effective intervention, the number of undesirable behaviours will distinctly decrease in the intervention phase and will typically return to the baseline level following the withdrawal of the intervention.

The advantages of using single-subject designs

Single-subject designs provide certain advantages relative to other research designs. Although concerns exist regarding the internal validity, external validity and generalisability of single-subject designs, many proponents of these designs nevertheless regard single-subject approaches as rigorous and scientific (Horner et al., 2005); these proponents argue that single-subject designs provide important methods of establishing evidence-based practices. Additionally, single-subject designs can be helpful for examining inferences that address the functional relationships between independent variables and measured behaviours.

Single-subject designs can provide a strong basis to confirm a functional relationship. However, it is not adequate to generalise this functional relationship to other settings,

times and persons. Therefore, meta-analytic studies can enhance the generalisability of single-subject designs findings within similar context. This can be done through 'statistical analysis of a large collection of results from individual studies for the purpose of integrating the findings' (Glass, 1976, p. 3).

The researcher's ability to control (compare) the experimental participants with themselves is one of the characteristics of single-subject designs that have caused these designs to be the predominant approaches that are described in the experimental special education literature. This characteristic allows the researcher to overcome the heterogeneous nature of the special education student population, which can pose great difficulties in the construction of matching groups for the purposes of comparisons. Another reason that single-subject designs are widely used in special education is that several types of these designs can generate causal inferences (Kratochwill, Hitchcock and Horner et al., 2010).

Causal and functional inferences regarding changes in student outcomes are significant aspects of building evidence-based practices in special education (Tankersley et al., 2008); these topics have received a great deal of attention in the special education field in recent years (Odom et al., 2005). However, it is challenging to define criteria that can prove the effectiveness of evidence-based practices that have arisen from single-subject designs, in fact, it is debatable whether this task is even possible.

In addition, the fact that single-subject designs possess high internal validity but can be accomplished in a cost-effective manner causes these designs to represent an attractive alternative to traditional experimental designs, which require much larger sample sizes (Simonsen and Little, 2011). Moreover, single-subject designs are flexible and can be adapted to various situations and educational settings, allowing the progress of experimental subjects to be monitored in actual educational contexts.

Single-subject designs are 'a rigorous, scientific methodology used to define basic principles of behavior and establish evidence-based practices. A long and productive history exists in which single subject research has provided useful information for the field of special education' (Horner et al., 2005, p. 165).

In single-subject research designs, 'as opposed to quasi- or pre-experimental designs, inferences can be drawn about functional relationships between independent variables and measured behaviors'(Wolery et al., 2011, p. 103), thus, to the extent that causal inferences can be drawn from any research method, these inferences can also be gleaned from single-subject research.

One of the reasons that single-subject designs are widely used in the fields of school psychology and special education is that in contrast to several other research designs, Single-subject designs can provide causal inferences based on results (Kratochwill et al., 2010). These inferences regarding changes in student outcomes that are caused by experimental treatments are valuable for establishing evidence-based practices in special education (Tankersley et al., 2008).

Horner et al. (2005) listed the following five prerequisites that single-subject designs must satisfy to enable the documentation of evidence-based practices:

> *'(a) the practice is operationally defined; (b) the context in which the practice is to be used is defined; (c) the practice is implemented with fidelity; (d) results from single-subject research document the practice to be functionally related to change in dependent measures; and (e) the experimental effects are replicated across a sufficient number of studies, researchers, and participants to allow confidence in the findings.'* (p. 175)

In recent years, the identification of evidence-based practices has received considerable attention in the special education field (Odom et al., 2005). It is widely agreed that evidence in special education should be obtained through the experimental validation of particular strategies (Maggin et al., 2011). However, the defining criteria for the documentation of evidence-based practices remain controversial (Maggin et al., 2011).

According to Simonsen and Little (2011), the use of single-subject designs provides a method to examine interventions for exceptional populations 'because it allows for a small sample size while maintaining high internal validity' (p. 161). Similarly, Pace and Colbert (1996) indicated that the use of single-subject designs helps manage the costs of treatment (Alberto and Troutman, 2006). In general, the cost-effectiveness of single-subject designs derives from their ability to both examine small sample sizes and maintain the use of a rigorous methodology (Horner et al., 2005).

Another advantage of using single-subject designs is the flexibility of these designs to adapt to varying situations and educational settings. This flexibility allows progress to be monitored in applied settings rather than in experimental contexts.

Issues and concerns

Although there are advantages to using single-subject designs, these designs also present certain limitations that must be considered. These limitations are discussed in the following section.

External validity

Although the external validity of the results from single-subject designs can be enhanced by replicating experiments across different conditions, participants and different measurements of the dependent variable (Horner et al., 2005), concerns regarding this external validity nonetheless remain the preeminent issue of single-subject research designs. '*External validity* examines whether or not an observed

causal relationship should be generalised to and across different measures, persons, settings, and times' (Calder, Phillips and Tybout, 1982, p. 240).

The focus on individuals as opposed to a group can be regarded as an advantage in single-subject research designs, particularly in special education, a field that continually features a focus on individual interventions or practices. However, this focus on individuals can also be perceived as a weakness of single-subject designs (Engel and Schutt, 2008) because it raises the issue of external validity. In addition, this focus on individuals raises concerns regarding the generalisability of the results that are obtained from single-subject research (Engel and Schutt, 2008). Nevertheless, Horner et al. (2005) indicated that the external validity issue can be solved by repeatedly testing experimental effects across a variety of participants and settings.

Furthermore, this statistical problem can also be addressed by developing meta-analytic studies to assess single-subject designs within the same context and aggregate the findings of these experiments (Engel and Schutt, 2008). Therefore, there is a growing interest in single-subject meta-analysis in psychology, education and special education. However, there is still no current consensus regarding the best meta-analysis procedures or techniques (Campbell, 2013).

In addition, Simonsen and Little (2011) suggested that the replication of treatment effects across multiple participants and studies would suffice to overcome concerns about the limited generalisability of the results from single-subject experiments which involve small sample sizes. Barlow and Hersen (1984) suggested three strategies to improve the external validity of single-subject designs. Direct replication involves repeating a previously completed study with the same (1) procedures, (2) providers of treatment and (3) setting; thus, in direct replications, the only change in the experiment is the use of different experimental participants who have similar characteristics. Systematic replication involves the repetition of a study in different settings; these replications involve different treatment providers than a previously completed study and examining behaviours that are related to but not identical to the behaviours that were examined in this initial study. Clinical replication is defined 'as combining different interventions into a clinical package to treat multiple problems' (p. 240). This replication occurs in the same setting as a previously completed study and involves participants who have problems that are similar to the problems of the participants in this initial study (as cited in Engel and Schutt, 2008).

Internal validity

Internal validity in a research design is essential for drawing causal inferences from the results. Internal validity in single-subject designs can be improved through the replication of these studies (Kratochwill et al., 2010). In addition, it is possible to employ sample randomisation in single-subject designs, although this technique remains uncommon. Therefore, replication is an important mechanism in single-subject designs to enhance internal validity, which are regarded as one of the limitations of this type of research (Kratochwill et al., 2010).

Horner et al. (2005) offered three suggestions for bolstering internal validity in single-subject designs: '(1) the design provides at least three demonstrations of experimental effect at three different points in time, (2) the design controls for common threats to internal validity, and (3) the results document a pattern that demonstrates experimental control' (p. 174).

Data analysis via visual inspection

The visual aspect of single-subject design results simplifies the analysis process and is therefore appealing to researchers. It is clear that at times, visual presentations can be more valuable than statistics for helping readers to understand experimental results. Kratochwill et al. (2010) defined six features that could be evaluated within and between phases: level, trend, variability, immediacy of the effect, overlap and consistency of data patterns across similar phases (Kratochwill et al., 2010). Differences between baseline and intervention phase in these features indicate an affect for the intervention (for more details on the visual analysis, see Horner et al., 2012).

Engel and Schutt (2008) identified five challenges or limitations of using visual interpretations for single-subject design findings. First, if the baseline phase includes a wide range of scores, it can be difficult to determine whether the intervention has produced a difference. Second, the changes that occur in the intervention phase may not be immediately evident. Third, if there is improvement in the participant's performance during the baseline phase, this improvement may be caused by reasons other than the study intervention; for instance, maturation may cause participant performance to improve regardless of the presence or absence of an intervention. Fourth, graphs can sometimes lead to misrepresentations of results and the acquisition of inaccurate conclusions. Fifth, 'the nature of the graph may prevent small but meaningful changes from being visually evident' (p. 225).

In summary, external validity is a major concern in single-subject designs. Although the focus of these designs on the individual instead of a group causes these designs to be popular in special education, this focus is nonetheless regarded as a weakness (Engel and Schutt, 2008) with respect to external validity. However, the external validity issue can be minimised by testing experimental effects in studies that are replicated across participants and settings (Horner et al., 2005). Barlow and Hersen (1984) have suggested three replication strategies for enhancing the external validity of single-subject designs: direct replication, systematic replication and clinical replication. In addition, it is important for meta-analytic studies to be developed in the special education field to aggregate results from different researchers who have conducted single-subject designs (Jenson, Clark and Kircher et al., 2007). The replication of observed effects across multiple participants and studies

will address the issues of small sample size and the limited generalisability of experimental results.

Conclusion

Single-subject designs have been one of the most commonly used methodologies in special education over the course of the past three decades and will continue to be used in future research. Single-subject designs undoubtedly help to fill the gap in the experimental literature in the field of special education. The use of each study participant as his/her own control to examine treatment effectiveness is the main distinction between single-subject designs and other research methodologies. This feature of single-subject designs renders them a particularly suitable alternative for special education research because special education students are not a homogeneous population. The ability to establish a control for each participant in a study helps researchers in the special education field overcome the issues that are presented by the heterogeneity of special education students.

Single-subject designs are tools for researchers and educators to examine the effectiveness of an intervention for a single individual. Single-subject designs have three essential pillars: replicated measurements (multiple instances of data collection), a baseline phase (A) and an intervention phase (B). There are four types of single-subject designs that can be used in special education: basic A-B designs, withdrawal designs, multiple baselines designs and multiple probe designs. These designs offer many positive features and potential benefits for the special education field; however, these types of experiments also possess certain limitations that merit consideration.

In single-subject designs, repeated measurements control for the potential threat to internal validity; the baseline continues until there is a clear pattern, which typically involves a minimum of three measurements. Data analysis of single-subject designs typically involves the visual study of graphical representations of the measured quantities in each study; these examinations attempt to identify level, rate or direction changes in the graph trend line that would indicate the effectiveness of a tested method of intervention. Finally, the generalisation of the findings from single-subject designs requires direct replication, systematic replication and clinical replication.

Recommendations

A number of recommendations can be drawn from this literature review of the use of single-subject designs in special education. First, there is a need for more meta-analyses that focus on single-subject design studies in each specific area of special education. The aggregation of results from many studies testing similar treatments for students with similar disabilities will help to validate the effectiveness of these treatments and promote the use of these interventions for students with disabilities. It is valuable if one study of a certain intervention establishes functionality, but it is more valuable if this functionality is established through a meta-analysis of several studies with the same intervention. This can provide evidence-based practice in special education with more confidence.

Second, the interpretation of the results of single-subject designs should not rely solely on visual interpretation; instead, there is a need for visual interpretation to be accompanied by other methods of interpreting these results. Third, there is a need to replicate single-subject studies adequately before offering generalisations regarding the effectiveness of a particular treatment method or intervention.

Fourth, the basic design (A-B) should be considered a last resort for single-subject research initiatives after all of the other types of these designs have been considered because this basic design is limited and does not allow for causal inferences to be obtained. Therefore, at a minimum, an extra baseline phase should be added to the basic design (creating an A-B-A design) to test whether the withdrawal of the intervention has an effect on the dependent variable. However, in certain scenarios, it is difficult and unethical to withdraw an intervention. To address these scenarios, a multiple baseline design should be employed. Finally, the increase of the number of baseline or intervention phases in an experiment until a clear pattern can be observed may be required in certain situations.

Limitations of the study

This study is limited to literature from 2000 and beyond because of the time constraints that are applicable with respect to this paper; however, several resources that were published prior to 2000 were added because the researcher felt that these resources were essential. In addition, the interpretations and conclusions of this study are limited to the special education field; the study conclusions and recommendations may not be applicable to other topics.

Address for correspondence
Ghaleb H. Alnahdi,
Special Education Department, College of Education,
Salman bin Abdulaziz University,
P.O. Box 176 Al-Kharj 11942,
Saudi Arabia.
Email: g.alnahdi@sau.edu.sa.

References

Alberto, P. A. & Troutman, A. C. (2006) *Applied Behavior Analysis for Teachers*. (7th edn). Upper Saddle River, NJ: Merrill.

Barlow, D. H. & Hersen, M. (1984) *Single Case Experimental Designs*. (2nd edn). New York: Pergamon Press.

Calder, B. J., Phillips, L. W. & Tybout, A. M. (1982) 'The concept of external validity.' *The Journal of Consumer Research*, 6, pp. 240–4.

Campbell, J. M. (2013) 'Commentary on PND at 25.' *Remedial and Special Education*, 34 (1), pp. 20–5.

Crano, W. D. & Brewer, M. B. (2002) *Principles and Methods of Social Research*. Mahwah, NJ: Psychology Press.

Engel, R. J. & Schutt, R. K. (2008) *The Practice of Research in Social Work*. Thousand Oaks, CA: Sage.

Gast, D. L. (2009) *Single Subject Research Methodology in Behavioral Sciences*. New York, NY: Routledge.

Glass, G. V. (1976) 'Primary, secondary, and meta-analysis of research.' *Educational Researcher*, 5, pp. 3–8.

Hammond, D. & Gast, D. L. (2010) 'Descriptive analysis of single subject research designs: 1983–2007.' *Education and Training in Autism and Developmental Disabilities*, 45 (2), pp. 187–202.

Hitchcock, J. H., Nastasi, B. K. & Summerville, M. (2010) 'Single-case designs and qualitative methods: applying a mixed methods research perspective.' *Mid-Western Educational Researcher*, 23 (2), pp. 49–58.

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S. & Wolery, M. (2005) 'The use of single-subject research to identify evidence-based practice in special education.' *Exceptional Children*, 71 (2), pp. 165–79.

Horner, R. H., Swaminathan, H., Sugai, G. & Smolkowski, K. (2012) 'Considerations for the systematic analysis and use of single-case research.' *Education and Treatment of Children*, 35 (2), pp. 269–90.

Jenson, W. R., Clark, E., Kircher, J. C. & Kristjansson, S. D. (2007) 'Statistical reform: evidence-based practice, meta-analyses, and single subject designs.' *Psychology in the Schools*, 44 (5), pp. 483–93. doi:10.1002/pits.20240.

Kratochwill, T. R., Hitchcock, J., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M. & Shadish, W. R. (2010) *Single-case design technical documentation*. Washington, D.C.: What Works Clearinghouse. <http://ies.ed.gov/ncee/wwc/pdf/wwc_scd.pdf> (accessed 13 September 2013).

Maggin, D. M., O'Keeffe, B. V. & Johnson, A. H. (2011) 'A quantitative synthesis of methodology in the meta-analysis of single-subject research for students with disabilities: 1985–2009.' *Exceptionality*, 19 (2), pp. 109–35. doi:10.1080/09362835.2011.565725.

McMillan, J. H. (2004) *Educational Research: Fundamentals for the Consumer*. (4th edn). Boston: Allyn and Bacon.

Odom, S. L., Brantlinger, E., Gersten, R., Horner, R. H., Thompson, B. & Harris, K. R. (2005) 'Research in special education: scientific methods and evidence-based practices.' *Exceptional Children*, 71 (2), pp. 137–48.

Pace, G. M. & Colbert, B. (1996) 'Role of behavior analysis in home and community-based neurological rehabilitation.' *The Journal of Head Trauma Rehabilitation*, 11 (1), pp. 18–26.

Parker, A. T., Grimmett, E. S. & Summers, S. (2008) 'Evidence-based communication practices for children with visual impairments and additional disabilities: an examination of single-subject design studies.' *Journal Of Visual Impairment & Blindness*, 102 (9), pp. 540–52.

Simonsen, B. & Little, C. A. (2011) 'Single-subject research in gifted education.' *Gifted Child Quarterly*, 55 (2), pp. 158–62. doi:10.1177/0016986211398331.

Tankersley, M., Harjusola-Webb, S. & Landrum, T. J. (2008) 'Using single-subject research to establish the evidence base of special education.' *Intervention in School & Clinic*, 44 (2), pp. 83–90.

Wolery, M., Dunlap, G. & Ledford, J. R. (2011) 'Single-case experimental methods: suggestions for reporting.' *Journal of Early Intervention*, 33 (2), pp. 103–9. doi:10.1177/1053815111418235.