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An Evaluation of Various SAFMEDS Procedures

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AN EVALUATION OF VARIOUS SAFMEDS PROCEDURES

by

Shawn Patrick Quigley

A dissertation submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
Psychology
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Shawn Patrick Quigley Ph.D.

Western Michigan University, 2014

Lindsley developed Say-All-Fast-Minute-Every-Day-Shuffled, or SAFMEDS, in the late 1970’s to enhance the typical use of flashcards (Graf & Auman, 2005). The acronym was developed specifically to guide the learner’s behavior when using flashcards. A review of SAFMEDS research indicates it has been utilized with children, college students and older adults with and without disabilities. The literature also indicates the SAFMEDS procedures used are not well documented or have multiple variations limiting practitioners’ ability to know what procedure to use and when. Furthermore, future SAFMEDS research is hampered by variations in the independent variable (i.e., SAFMEDS). The purpose of this study was to evaluate a basic SAFMEDS procedure and four supplementary SAFMEDS procedures. Results of the study suggest the basic SAFMEDS procedure was not sufficient for developing fluent responding with Chinese characters or Russian words, but all of the supplementary procedures led to increases in the number of correct responses per 1-min timing. Further research evaluating differences in performance across the supplementary procedures is warranted.

Keywords: SAFMEDS, flashcards, precision teaching, self-study
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Many individuals have supported my educational endeavors through the years. I hope these words convey my gratitude to each of them.

My wife Myra and my three children, Kylie, Shawn Jr. and Paul Jr. have endured many days and nights without a husband and father so that I could pursue my education. This journey started 8 years ago with the idea that the more education I had, the better our chances would be to have a lifestyle where I could be an active husband and father. Here is to looking forward with an eye toward accomplishing our family goals. The greatest work I will do will be within the walls of my own home.

I am forever in debt to my advisor Dr. Stephanie Peterson. Dr. Peterson has repeatedly exemplified her motto of “Wag more and bark less.” Her encouragement and ability to find solutions through positive interactions is astounding. I will never forget her ability to move forward with the hope there is something worth fighting to save. I hope I can continue to develop and refine even a small portion of these characteristics.

Immense gratitude is extended to Dr. Lloyd Peterson. Dr. Peterson started me on this journey and has been present every step of the way providing mentorship far beyond my education. His enthusiasm and championing of being “behavior builders” is second to none. I hope I can follow in his footsteps and see the potential each individual has and through my actions help each individual reach his/her potential. I am privileged to be his “favorite.”
Acknowledgements – Continued

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Shawn Patrick Quigley
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INTRODUCTION

Precision Teaching (PT) is a supplemental strategy for instruction emphasizing frequent measurement of student performance, which in turn, allows teachers to make instructional decisions (Merbitz, Vieitez, Merbitz & Pennypacker, 2004; West, Young & Spooner, 1990). Within PT, the focus of measurement is fluency (i.e., accuracy and speed) as opposed to accuracy alone, because fluency-based instruction is purported to have better outcomes. Some of the reported effects of fluency-based instruction are retention of information, endurance of performance, stability of performance in the face of challenges (e.g., external noises from other students), and application of material to novel situations. REAPS (Retention, Endurance, Application, Performance standards and Stability) is often an acronym used to reflect these outcomes (Lindsley, 1992).

One particular PT strategy is Say-All-Fast-Minute-Every-Day-Shuffled or SAFMEDS. SAFMEDS is an instructional and assessment strategy similar to flashcards. Lindsley coined the term in the late 1970’s to specify procedural differences between SAFMEDS and traditional flashcard procedures (Eshleman, 2000a; Graf & Auman, 2005). The acronym suggests all cards (i.e., all material to be learned, not just what is being learned presently) are to be said aloud (i.e., an overt response; typically a vocal response but typing, pointing, or clicking also have been used) within a brief time period (e.g., 1 min, which allows for fluency development as opposed to just accuracy) every day after shuffling the cards (to help prevent serial learning). Some might equate this to “flashcards,” however, flashcard procedures are different from SAFMEDS in that the practice process is less structured and doesn’t necessarily emphasize these important areas of instruction.
Eshleman (2000a) and Graf and Auman (2005) have provided basic instructions for the SAFMEDS procedure. The learner manipulates the deck (i.e., holds it, moves cards, sorts cards, etc.), shuffles the cards, starts the timer, “sees” the stimulus and “says” the correct response (other learning channels can be used; see Graf & Auman for further discussion), checks the accuracy of the response by turning the card over, sorts the cards into “correct” and “not yet” piles, and continues this process until the time has expired. Upon completion of the timing the learner counts the cards in each pile, charts the data (typically on a Standard Celeration Chart; see Calkin, 2005 for more information), and analyzes the data. The purest SAFMEDS procedure (based strictly upon the guidelines suggested within the acronym) would consist of single 1-min timing per day following the above procedures. In their how-to guides, however, Eshleman (2000a) and Graf and Auman (2005) provide other examples of what SAFMEDS instruction and assessment might look like (e.g., multiple timings in a single day, study prior to a timed review).

Since its inception, SAFMEDS has been the focus of various research projects aimed at evaluating performance (e.g., Bolich & Sweeney, 1996; Byrnes, Macfarlane, Young & West, 1990; Eaton & Fox, 1983; Eshleman, 1985), extended outcomes of the learning (i.e., REAPS, Kim, Carr & Templeton, 2001; Olander, Collins, McArthur, Watts, & McDade, 1986), comparison of different SAFMEDS procedures (e.g., teacher versus student deck development, McDade & Olander, 1990), comparison of different modalities (e.g., computer-based versus paper deck, McDade, Austin & Olander, 1985), and factors affecting performance outcomes (e.g., error rate, Bower & Orgel, 1981; stimulus control, Meindl, Ivy, Miller, Neef & Williamson, 2013). A review of this literature indicates SAFMEDS can increase fluent performance with varied content (e.g.,
math facts, reading fluency, positive self-statements) across various populations (i.e., elementary education, secondary education, university and geriatric), and settings (e.g., education, home and community; Quigley, Peterson, & Frieder, in preparation). In spite of these various applications, however, there are several limitations to the SAFMEDS literature base.

First, SAFMEDS is an instructional and assessment strategy that has been in existence for at least 30 years, yet there is a relatively small number of peer-reviewed publications evaluating effectiveness. In a review of the SAFMEDS literature, Quigley, Peterson and Frieder (in preparation) identified only 27 peer-reviewed SAFMEDS publications spanning from 1980 to 2014 using multiple database searches, reverse citation procedures, website reviews, and listserv inquiries. In contrast, searching only a single database using the term “flashcards” yielded 48 peer-reviewed publications. The effort required to obtain the meager 27 SAFMEDS publications as compared to the ease with which the 48 flashcard studies could be identified suggests research related to SAFMEDS is not prevalent and is difficult to obtain. In discussing the broad domain of fluency research, Binder (1996) stated the effects of fluency-based instruction were not well represented in scientific literature, namely because it was typically disseminated outside of the peer-review publication process (e.g., chart sharing). The same can likely be said of SAFMEDS, as it is a specific fluency-based strategy.

Second, some of the research strategies used in the SAFMEDS literature are not consistent with the well-accepted procedures documented in other behavioral publications. For example, interobserver agreement (IOA) and integrity measures of the independent variable are typically absent in the SAFMEDS literature (Quigley, Peterson,
& Frieder, in preparation). One reason for this absence might be fluency research has a strong applied focus (Binder, 1996). The publications are overwhelmingly focused upon implementing SAFMEDS to solve real world problems. Given the very applied focus of this research, it may be difficult to satisfy the experimental expectations for publishable research. Additionally, as stated above, the focus of dissemination in PT has not traditionally been via the traditional peer-review process. Rather, dissemination has been through an informal, “chart-share” process.

Third, many of the published SAFMEDS studies rely upon a “behavioral dynamics” research methodology to determine the outcomes of the strategy. The concern here is not with the use of the behavioral dynamics methodology itself (although it concerns others; see Cooper, 2005, for further discussion). Rather, the concern is whether one can draw meaningful conclusions regarding purported outcomes within a behavioral dynamics methodology. Behavioral dynamics provides evidence of relationships at the correlational level of research (Cooper, 2005; Kubina, 2012). Specifically, the basic premise is that the more frequently two variables are documented as co-occurring, the greater the likelihood the observed changes are a result of the two variables together and not from other variables. As Cooper, Heron, and Heward (2007) stated, “Replication is the primary method with which scientists determine the reliability and usefulness of their findings and discover their mistakes” (p. 6). Even if one accepted the behavioral dynamics research methodology, given only 27 published examples of SAFMEDS, replication of the correlational relationship between SAFMEDS procedures and increased fluency appears to be minimal.
Finally, attempts at replication require the two variables under investigation to remain as consistent as possible across experiments to draw more definitive conclusions. The limited SAFMEDS research utilized different populations (e.g., children, adolescents, young adult, and geriatric), different materials (e.g., paper, computer), different content areas (e.g., reading, math, science, positive thoughts), different settings (e.g., education, home, community), and different response modalities (e.g., vocal, writing, thinking). Most importantly, in relation to this research project, is the lack of clear procedural guidelines for SAFMEDS implementation across the studies. A review of two guidelines for SAFMEDS (i.e., Eshleman, 2000a; Graf & Auman, 2005) reveals the following common procedures for implementation:

1) Learner holds the deck

2) Shuffle the cards

3) Start the timer (different options for time length but typically 1-min)

4) “See” front and out loud “say” the back (although other learning channels can be used)

5) Turn the card over and check answer for immediate feedback (not checking answers during the timing is also advocated)

6) Sort correct and incorrect responses into piles

7) After the time expires, count the number of responses per pile

8) Chart performance for review and instructional changes

9) Utilize various strategies for additional practice/instruction in conjunction with the 1-min timing (additional practice/instruction can be before and/or after the timing)
The above steps represent a basic strategy. Any of the steps could be altered to facilitate learner performance. For example, the above authors suggest the timing length can be a count down (i.e., 1-min is the time, the timer counts down, and the time beeps upon expiration) or count up procedure (i.e., a stop watch is started, time counts up from 0 and continues until all cards in the deck have been reviewed). A count down procedure provides a consistent measurement period but likely limits the number of cards the learner experiences. A count up procedure allows the learner to see every card but yields different measurement periods. These simple changes in the timing procedure might affect learner performance.

As stated by Quigley, Peterson and Frieder (in preparation), there are several inconsistencies within the SAFMEDS procedures. In order to better address the relation between SAFMEDS and student performance more research, controlling for procedural variations, is needed. The purpose of this study was to evaluate the effects of four supplementary SAFMEDS procedures as compared to the basic SAFMEDS procedure on the number of responses during a 1-min timing. The four supplementary procedures were alterations of the number of cards available in the deck at one time (i.e., incremental and non-incremental) and study procedures outside of a 1-min timing (i.e., whole and sprints). Specifically, there were five questions of interest for this study:

1) What are the effects of a basic SAFMEDS procedure on the number correct and incorrect responses to either Russian or Chinese characters and their English-language equivalents in graduate and undergraduate students?

2) What are the effects of a whole-deck review SAFMEDS procedure on the number correct and incorrect responses in college students?
3) What are the effects of an incremental whole-deck review SAFMEDS procedure on the number correct and incorrect responses in college students?

4) What are the effects of a sprints SAFMEDS procedure on the number correct and incorrect responses in college students?

5) What are the effects of an incremental sprints SAFMEDS procedure on the number correct and incorrect responses in college students?
METHOD

Participants

Nineteen participants who were students enrolled at a Midwest university were recruited through flyers and in-class recruitment scripts agreed to participate in this study. However, only 14 completed the study. The students’ educational backgrounds (e.g., G.P.A, enrollment status), familiarity with SAFMEDS, and histories with a second language varied (see Table 1 for a summary). Criteria for inclusion in the study consisted of the participants possessing basic reading skills, vocal language skills, no physical disabilities that limited hand/finger dexterity, no visual impairments, and no history of learning related to the Russian and Chinese languages (i.e., they had no formal training in either language, neither language was a language spoken at home, and they had not lived in a location where the language was used). The inclusionary criteria were assessed via a questionnaire.

Table 1
Participant Demographics

<table>
<thead>
<tr>
<th>BA/BS</th>
<th>Masters</th>
<th>Ph.D.</th>
<th>GPA &lt; 3.0</th>
<th>GPA &gt; 3.0</th>
<th>Second Language Training</th>
<th>Years of Training &lt; 2</th>
<th>Years of Training &gt; 2</th>
<th>SAFMEDS History</th>
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<td>1</td>
<td>2</td>
<td>12</td>
<td>12</td>
<td>3</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Settings and Materials

Sessions were conducted in a room at the university. The room measured approximately 3 m x 2 m and contained tables and chairs. The participant and one or two researchers (a second researcher was occasionally present for live scoring for interobserver agreement purposes) were present for every session. Materials consisted of
two timers for timing (i.e., stopwatch and digital countdown timer), three different decks of SAFMEDS cards (i.e., training deck, Chinese deck and Russian deck), a demographics questionnaire for assessing inclusionary criteria (see Appendix B), a social validity questionnaire based upon Reimers and Wacker (1988; see Appendix C), and video recording equipment.

The SAFMEDS cards were approximately 7.6 cm x 12.7 cm and were created by printing the relevant information on both sides of cardstock and then cutting the cards out. The training deck consisted of 20 cards with a picture on one side and a term on the other. The picture/term combinations were created to train participants in the SAFMEDS procedure. In an attempt to train correct responses, some cards had a common picture on one side (e.g., a picture of a car) and a common term on the other side (e.g., car). In an attempt to train what the learner was to do if he/she made an incorrect response, some cards had a common picture on one side (e.g., picture of 18-wheel truck) with a relatively novel term on the side (e.g., big rig). Finally, in an attempt to train “pass” responses, some cards had an unfamiliar picture on one side (e.g., dragon fruit) with the corresponding term on the other side (e.g., dragon fruit). Examples of the training deck are provided in Appendix D.

The remaining two decks were created in a similar manner and differed only in terms of content and total number of cards. One deck had Mandarin Chinese characters on one side with the English translation on the opposite side. The second deck had Russian words on one side with the English translation on the opposite side. Both decks contained 60 cards with the same English words across decks (e.g., 月 = moon and Луна = moon; 山 = mountain and ropa = mountain; see Appendix E for a complete listing).
Correspondence between languages was determined via http://translate.google.com/. All information on the front and back of cards was formatted to the center of the card. To avoid spurious stimulus control issues (see Eshleman, 2000a, b; Meindl et al., 2013) multiple identical decks were created and rotated for use in each experimental session. Cards with any visible marks, smudges, tears, or other marks were replaced.

Dependent Variables

The dependent variables were the number of correct responses, incorrect responses, and passes. A correct response was when the participant stated, out loud, the term associated with the character/word on the other side of the card. For example, if the participant saw the Chinese character for boy, he/she needed to vocally state, “Boy” for a correct response to be scored. An incorrect response was when the participant stated a term other than what was printed on the card. For example, if the participant saw the Chinese character for boy and the participant said, “Girl,” this was counted as incorrect. Another example, if the participant saw the Chinese character for boy and the participant said, “Male,” this was counted as incorrect. If the participant provided more than one response for a single card, the final response was scored according to the above definitions. For example, if the participant saw the Chinese character for boy and said, “Girl…no Boy,” it was counted as correct so long as the final response occurred prior to the participant turning over the card. If no response occurred prior to the participant turning a card over it was counted as incorrect. Passes were counted in a similar manner to correct and incorrect. For example, if the participant saw the Chinese character for boy and said, “Pass,” it was counted as a pass. There were no time constraints, within the 1-
min timing, to produce a response for each individual card. That is, a participant could look at each card as long as he or she liked before answering.

Measurement of the Dependent Variables

The dependent variables were measured using a rate measure. Researchers scored every response as correct, incorrect or pass. The total number of responses per category was then summed. Correct, incorrect and pass responses per 1-min timing were reported. Data were scored live or via video review (see Appendix F for a copy of the data sheet).

Interobserver Agreement

A second researcher observed at least 25% of the sessions, distributed equally across phases for each participant. The second observer simultaneously, but independently scored corrects, incorrect, and passes. Interobserver agreement (IOA) was calculated using a point-by-point agreement method (Kazdin, 1982). Point-by-point agreement was determined by comparing data recorded for each individual participant response. The number of agreements was divided by the number of agreements plus disagreements and multiplied by 100 to yield an agreement percentage. IOA was averaged across all participants and phases for an overall agreement of 99% (range 89%-100%).

Experimental Design

The research questions were evaluated using a simultaneous treatment design embedded within in a concurrent multiple baselines across participants design (Kazdin, 1982). The simultaneous treatment design allowed for within subject comparison of the basic SAFMEDS procedure to a supplementary SAFMEDS procedure. Within participant treatment effects across SAFMEDS procedures were determined by comparing the trend
of correct, incorrect and pass responses across the treatments. Sooner changes in trend and steepness of trend were interpreted as more rapid learning from a SAFMEDS procedure. The multiple baseline design provided the opportunity for replication of effects across SAFMEDS procedures. Similar changes in performance trends, at different points of time and across participants were interpreted as an indication that the changes were a result of the SAFMEDS procedure as opposed to other variables. Each participant was exposed to the basic SAFMEDS procedure first, and then one of the supplemental SAFMEDS procedures was alternated with the basic procedure. Each participant completed timings for both the Russian and Chinese decks, but whether the basic SAFMEDS procedure or the supplemental SAFMEDS procedure was implemented for Russian vs. Chinese was counterbalanced across participants.

Independent Variables

Basic SAFMEDS Procedure

The basic SAFMEDS procedures were based upon Eshleman (2000a), Graf (2005) and the authors’ personal experience with SAFMEDS. Specifically, participants held the deck, shuffled the deck, started a count down timer (which was set for 1 min), looked at the stimulus (Russian or Chinese) on the front side of the card (i.e., see), provided a vocal response (i.e., say), flipped the card over to determine if the answer (English equivalent) was correct or incorrect, placed the card into a pile (i.e., correct, incorrect or pass), and repeated the procedure with the as many cards as possible during the 1-min timing. Participants were told, “You will have 1 min to say as many terms as you can. If you don’t know the term you can pass on the card. If you pass, you should still flip the card over to see the correct response.” The basic SAFMEDS procedures were
conducted one time per day for each deck (i.e., Chinese and Russian). It was hoped that timings would be conducted daily (as indicated by the “every day” portion of the acronym) but logistics prevented meeting every day with every participant. Timings were limited to Monday through Friday. Participants could have been provided the decks to use on their own every day, but that would have prevented the researchers from ensuring similar access to the material across participants. It is possible the students could have studied the material without the cards (e.g., internet, books at the library) but this was considered less likely to occur. The supplemental procedures (described below) were all compared against this basic SAFMEDS procedure.

Whole Deck Supplemental Procedure

The participant was given the opportunity to view and provide a response to every card in the deck in as little time as possible prior to the 1-min timing. A hypothesized benefit of this procedure was that learners were able to experience every card in the deck, thereby providing more learning opportunities than what would be experienced completing just the 1-min timing (Eshleman, 2000a). Specifically, participants were told, “Review each card as quickly as possible. If your review continues for 10 minutes you will be stopped.” Following the completion of the whole deck review participants completed the 1-min timing as outlined in the basic SAFMEDS procedure described above. Participants did not have any additional exposure to the cards before, after or between the timings.

Incremental Whole Deck Supplemental Procedure

Incremental whole deck was identical to the whole deck procedure except the participant was only given a portion of cards from the deck. The whole deck contained 60
cards, but during the incremental whole deck procedure, participants were only given 15 cards at a time. This procedure was an extension of procedures in Kim, Carr and Templeton (2001) and was hypothesized to have the benefit of placing lower instructional demand on the participants and more repeated practice on a smaller number of cards at one time. The instructions for the incremental whole deck procedure were the same as the whole deck procedure. The basic SAFMEDS procedure was identical except the deck only contained the 15 cards provided during the whole deck review period. There were still 60 cards in the deck during the 1-min timing; however four duplicates of each of the 15 cards were used. Participants were given 15 new cards (not cumulative, the original 15 were withheld) when participants had an increasing trend for corrects and decreasing trend for incorrect for at least three consecutive 1-min timings. In addition, the number of correct responses had to be higher than incorrect responses. When the participant had been exposed to each of the four sub decks of 15 cards, all 60 cards were recombined, and the procedure was then identical to the whole deck supplemental procedure. Participants did not have any additional exposure to the cards before, after or between the timings.

Sprints Supplemental Procedure

This procedure was identical to the basic SAFMEDS procedure except the number of timings conducted within a single day increased. This procedure was based upon Eshleman (2000a), Stockwell and Eshleman (2010) and the authors’ collective experiences with SAFMEDS and was hypothesized to have the additional benefit of increased practice opportunities for participants. Participants completed three timings prior to a fourth testing timing in a back-to-back fashion (i.e., four 1-min sprints through
the material). Only performance on the final timing was recorded. Participants did not have any additional exposure to the cards before, after or between the timings.

Incremental Sprints Supplemental Procedure

This procedure was identical to the sprints supplemental procedure except the participant was only given a portion of cards from the deck. This procedure was an extension of procedures in Kim, Carr and Templeton (2001) and was hypothesized to have the benefit of both a smaller number of cards to master at any given time, as well as additional practice opportunities. The deck typically contained 60 cards, but participants were only given 15 cards at a time. Four duplicates of each of the 15 cards (for a total of 60 cards) were used during the 1-min timings. Participants were given 15 new cards (not cumulative, the original 15 were withheld) when participants had an increasing trend for corrects and decreasing trend for incorrect for at least three consecutive 1-min timings. In addition, the number of correct responses had to be higher than incorrect responses. When the participant had been exposed to each sub deck, all cards were recombined and the procedure was identical to the sprints supplemental procedure. Participants did not have any additional exposure to the cards before, after or between the timings.

Fidelity of the Independent Variable

To ensure accurate implementation of the above SAFMEDS procedures, a fidelity checklist was developed (see Appendix G). The checklist was used to determine if key procedural aspects of each SAFMEDS procedure (e.g., shuffling, number of timings, duration of timing, sorting of cards into correct piles) were followed across sessions and participants. A researcher observed video recordings of at least 25% of SAFMEDS sessions and completed the fidelity checklist. A second observer conducted fidelity
checks in a similar manner for at least 25% of sessions already scored for fidelity to determine fidelity IOA. Fidelity IOA was calculated using a point-by-point agreement method (Kazdin, 1982). Fidelity was averaged across all participants and phases for an overall score of 98% (range 80%-100%). Fidelity IOA was averaged across all participants and phases for an overall agreement of 99% (range 80%-100%).

Procedures

Consent and Demographics

The project was reviewed and approved by the university’s Human Subjects Institutional Review Board. Interested individuals were given the opportunity to provide informed consent, and the first 19 who did were the participants in this study. At the time of consent, participants completed the demographics questionnaire to determine eligibility.

Basic SAFMEDS Procedure Training

Participants were trained on the basic SAFMEDS procedure with the training deck. Specifically, participants were instructed how to hold the deck, shuffle the deck, start a countdown timer, look at the stimulus on the front side of the card (i.e., see), provide a vocal response (i.e., say), flip the card over to determine if the answer was correct or incorrect, place the card into a pile (i.e., correct, incorrect or pass), and repeat the procedure with the as many cards as possible during the 1-min timing. In addition to vocal instruction, participants watched a video demonstration of the basic SAFMEDS procedure, and the researcher modeled the procedure. All participants demonstrated fidelity on the basic SAFMEDS procedure in four or fewer practice timings. The training
phase concluded when participants had at least 20 responses (correct, incorrect, and passes totaled) per min with 80% or higher fidelity.

Basic SAFMEDS Procedure for Chinese and Russian Decks (Baseline)

Following successful completion of training, participants met as frequently as possible (hopefully daily, Monday through Friday) with a researcher to complete timings using the basic SAFMEDS procedure. The participant met with a researcher in a private room and completed a single 1-min timing with each deck following the basic SAFMEDS procedure. Order of the timings (i.e., Chinese deck timing then Russian deck timing) was not controlled. Further comments regarding this are provided in the discussion section. Sessions lasted less than 5 minutes. Participants only had access to the cards during the 1-min timing.

Introduction of a Supplemental SAFMEDS Procedure

When a participant had an increasing trend for corrects and decreasing trend for incorrect for at least three consecutive 1-min timings, and the number of correct responses were higher than incorrect responses the supplemental SAFMEDS procedures was introduced. The supplemental SAFMEDS procedure was introduced for one of the decks while the remaining deck continued with just the basic SAFMEDS procedure. The deck exposed to the supplemental procedure was counterbalanced across participants. When introducing a supplemental SAFMEDS procedure, performance on each deck was compared for each participant. The participant with the most stable and lowest performance (i.e., least upward trend in corrects) was introduced to a supplemental procedure for the lowest performing deck. The supplemental deck procedures were trained in a similar manner as training for the basic SAFMEDS procedure.
For example, three participants were randomly assigned to receive one of the supplemental procedures. Each participant completed a daily (or as frequently as possible if daily was not possible) single 1-min timing for each deck (i.e., Chinese and Russian). After two weeks, if performance data indicated a participant had low and stable performance, the supplementary SAFMEDS procedure assigned to that group was implemented for that participant. One of the decks (e.g., Chinese) for the participant now received the supplementary SAFMEDS procedure in conjunction with the basic SAFMEDS procedure. The second deck (e.g., Russian) continued with the basic SAFMEDS procedure. The other two participants continued in baseline, receiving the basic SAFMEDS procedures for both decks. When the second participant’s performance data was low and stable he/she received the supplementary SAFMEDS procedure for one of the decks. The second participant might receive the supplementary procedure for Russian, while the other deck (Chinese) continued with the basic SAFMED procedure. This was done to ensure that differences in performance were not due to the language, but rather to the practice procedure used. This procedure was followed for each group of individuals and supplemental procedures (i.e., whole deck, incremental whole deck, sprints, and incremental sprints).

Follow-up Phase

Participants continued with the basic SAFMEDS procedure for one deck and supplemental SAFMEDS procedure for the second deck until approximately two weeks before the end of the semester. Transition to the follow-up phase was based upon time criteria due to pragmatic concerns of having college students continue with the project beyond the end of the semester. After at least ten days with no practice, participants met
with a researcher and conducted a follow-up timing. Participants completed a single 1-min timing for each deck following the basic SAFMEDS procedure. The purpose of this phase was to briefly assess the short-term maintenance of performance following at least 10 days without access to the cards. In addition to completing the follow-up timings, all participants completed the social validity questionnaire.

RESULTS

For ease of presentation, the results are grouped by supplemental SAFMEDS procedure. Within each grouping, results of the basic SAFMEDS procedure for each participant are provided first, and then individual performance on the supplemental procedure is provided second. Table 2 provides summary data for each participant across supplemental SAFMEDS procedures.

Whole Deck Supplemental Procedure

Karly, Terri and Louise were assigned to the whole deck supplemental procedure in conjunction with the basic SAFMEDS procedure. For Karly and Louise, the Chinese deck was studied only via the basic SAFMEDS procedure whereas Terri studied the Russian deck only via the basic SAFMEDS procedure. Visual inspection of the participants’ basic SAFMEDS procedure data (see Figure 1) indicates a fairly flat trend across incorrect and pass responses and slight increasing trend for correct responses.

Participants were exposed to the whole deck supplemental SAFMEDS procedure between 4 and 8 weeks. Karly and Louise studied the Russian deck via the basic and supplemental SAFMEDS procedures whereas Terri studied the Chinese deck via the basic and supplemental SAFMEDS procedures. The rate of correct, incorrect and pass responses were somewhat varied across participants but overall trends were similar.
Visual inspection of the participants’ data (see Figure 2) indicates a decreasing trend across incorrect and pass responses across all participants, and a slight increasing trend in correct responses for Karly and steep increasing trends in correct responses for Terri and Louise.

**Table 2**

*Average Number of Correct Responses Across Participants*

<table>
<thead>
<tr>
<th>Participant Name</th>
<th>Training</th>
<th>Basic SAFMEDS (Deck with no supplementary procedure)</th>
<th>Basic SAFMEDS (Deck prior to supplementary procedure)</th>
<th>Supplementary SAFMEDS procedure</th>
<th>Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karly</td>
<td>22</td>
<td>2.6 (range 0-6)</td>
<td>.1 (range 0-1)</td>
<td>8.8 (range 2-19)</td>
<td>10</td>
</tr>
<tr>
<td>Terri</td>
<td>18</td>
<td>1.3 (range 0-5)</td>
<td>.5 (range 0-2)</td>
<td>19.7 (range 1-35)</td>
<td>19</td>
</tr>
<tr>
<td>Louise</td>
<td>40</td>
<td>2.0 (range 0-5)</td>
<td>.9 (range 0-2)</td>
<td>18.1 (range 1-31)</td>
<td>22</td>
</tr>
<tr>
<td>Jackson</td>
<td>33</td>
<td>.3 (range 0-2)</td>
<td>1 (range 0-3)</td>
<td>27.1 (range 9-42)</td>
<td>15</td>
</tr>
<tr>
<td>Bailey</td>
<td>18</td>
<td>3.4 (range 0-8)</td>
<td>0</td>
<td>23 (range 10-38)</td>
<td>1</td>
</tr>
<tr>
<td>Joan</td>
<td>19</td>
<td>1.3 (range 0-2)</td>
<td>1.4 (range 0-2)</td>
<td>32.1 (range 17-43)</td>
<td>3</td>
</tr>
<tr>
<td>Pam</td>
<td>23</td>
<td>3.5 (range 0-9)</td>
<td>0</td>
<td>26.2 (range 16-35)</td>
<td>7</td>
</tr>
<tr>
<td>Kit</td>
<td>14</td>
<td>1.1 (range 0-4)</td>
<td>0</td>
<td>11.5 (range 1-23)</td>
<td>N/A</td>
</tr>
<tr>
<td>Dianne</td>
<td>27</td>
<td>3.3 (range 0-7)</td>
<td>.5 (range 0-2)</td>
<td>9.4 (range 1-16)</td>
<td>12</td>
</tr>
<tr>
<td>Myra</td>
<td>17</td>
<td>1.9 (range 0-5)</td>
<td>0</td>
<td>2.2 (range 0-5)</td>
<td>6</td>
</tr>
<tr>
<td>Kylie</td>
<td>30</td>
<td>3 (range 0-9)</td>
<td>2 (range 0-5)</td>
<td>21.3 (range 1-32)</td>
<td>25</td>
</tr>
<tr>
<td>Nathan</td>
<td>28</td>
<td>1.7 (range 0-8)</td>
<td>.7 (range 0-2)</td>
<td>14.7 (range 3-33)</td>
<td>15</td>
</tr>
<tr>
<td>Sarah</td>
<td>21</td>
<td>3.9 (range 0-8)</td>
<td>0</td>
<td>15.7 (range 2-32)</td>
<td>14</td>
</tr>
<tr>
<td>Lacey</td>
<td>18</td>
<td>5.3 (range 0-9)</td>
<td>1.5 (range 0-3)</td>
<td>15.7 (range 5-27)</td>
<td>12</td>
</tr>
</tbody>
</table>

Incremental Whole Deck Supplemental Procedure

Jackson, Bailey, Joan and Pam were assigned to the incremental whole deck supplemental procedure in conjunction with the basic SAFMEDS procedure. For Jackson
and Joan, the Russian deck was studied via the basic SAFMEDS procedure only whereas Bailey and Pam studied the Chinese deck via the basic SAFMEDS procedure only.

Visual inspection of the participants’ data (see Figures 3 & 5) indicate a fairly flat trend across incorrect and pass responses, except for Joan, who showed an increasing trend across time. For correct responses, a slight increasing trend was seen for Bailey and Pam whereas Jackson and Joan have a flat trend.

Participants were exposed to the incremental whole deck supplemental SAFMEDS procedure between 4 and 6 weeks although the number of timings varied across participants. Jackson and Joan studied the Chinese deck via the basic and supplemental SAFMEDS procedures whereas Bailey and Pam studied the Russian deck via the basic and supplemental SAFEMDS procedures. The rate of correct, incorrect and pass responses were slightly varied across participants but overall trends were similar.

Visual inspections of the participants’ data (see Figures 4 and 6) indicate an abrupt downward level change across incorrect and pass responses, and an abrupt upward level change with an increasing trend in correct responses. Changes in performance across sub-decks varied across each participant but all participants showed high rates of performance with the sub-decks. When the sub-decks were recombined into the full deck all participants, except Bailey, had an abrupt downward level change followed by an increasing trend. Due to medical complications Bailey was only able to complete a single timing with the recombined deck. The first data point had a similar pattern of an abrupt downward level change.
Figure 1. Number of correct, incorrect and pass responses for Karly, Terri and Louise for the basic SAFMEDS procedure
Figure 2. Number of correct, incorrect and pass responses for Karly, Terri and Louise for the Whole Deck supplemental SAFMEDS baseline.
Sprints Supplemental Procedure

Kit, Dianne, Myra and Kylie were assigned to the sprints supplemental procedure in conjunction with the basic SAFMEDS procedure. For Kit and Kylie the Russian deck was studied via the basic SAFMEDS procedure only whereas Myra and Dianne studied the Chinese deck via the basic SAFMEDS procedure only. Visual inspection of Kit, Dianne and Myra’s data (see figures 7 and 9) indicate a fairly flat trend across incorrect and pass responses and slight increasing trend for correct responses. Visual inspection of Kylie’s data is similar except for a slight upward trend in the number of pass responses per 1-min timing.

Participants were exposed to the sprints supplemental SAFMEDS procedure between 3 and 5 weeks although the number of timings varied across participants. Kit and Kylie studied the Chinese deck via the basic and supplemental SAFMEDS procedures whereas Dianne and Myra studied the Russian deck via the basic and supplemental SAFEMDS procedures. The rate of correct, incorrect, pass responses and trends were similar for Kit, Dianne and Kylie. However, Myra had similar rates of incorrect and pass responses but had fewer corrects with a slight increasing trend. A visual inspection of the participants’ data (see figures 8 and 10) indicate a stable trend across incorrect and pass responses for Dianne and Kylie, an increasing trend in passes for Myra, and a decreasing trend in incorrect responses for Kit. Data for Kit, Dianne, and Kylie indicated a sharp to moderate increasing trend for correct responses. Myra has a very slight increase in correct responses that is similar to trends observed in the basic SAFMEDS procedures for all participants.
Figure 3. Number of correct, incorrect and pass responses for Jackson and Bailey for the basic SAFMEDS procedure.
Figure 4. Number of correct, incorrect and pass responses for Jackson and Bailey for the Incremental Whole Deck supplemental SAFMEDS procedure.
Figure 5. Number of correct, incorrect and pass responses for Joan and Pam for the basic SAFMEDS procedure.
Figure 6. Number of correct, incorrect and pass responses for Joan and Bailey for the Incremental Whole Deck supplemental SAFMEDS procedure.
Incremental Sprints Supplemental Procedure

Nathan, Sarah and Lacy were assigned to the incremental sprints supplemental procedure in conjunction with the basic SAFMEDS procedure. For Sarah and Lacey, the Chinese deck was studied only via the basic SAFMEDS procedure whereas Nathan studied the Russian deck only via the basic SAFMEDS procedure. Visual inspection of Sarah and Lacy’s data (see figure 11) indicate a fairly flat trend across incorrect and pass responses with a slight increasing trend in correct responses. A visual inspection of Nathan’s data indicates a decreasing trend in pass responses with a slight increasing trend in correct responses.

Participants were exposed to the incremental sprints supplemental SAFMEDS procedure between 5 and 6 weeks, although the number of timings varied across participants. Sarah and Lacey studied the Russian deck via the basic and supplemental SAFMEDS procedures whereas Nathan studied the Chinese deck via the basic and supplemental SAFEMDS procedures. The rate of correct, incorrect and pass responses were slightly varied across participants but overall trends were similar. Visual inspections of the participants’ data (see Figure 12) indicate an abrupt downward level change across incorrect and pass responses, and an abrupt upward level change with an increasing trend in correct responses. These patterns were fairly consistent each time a sub-deck was changed. When the sub-decks were recombined into the full deck, all participants had an abrupt downward level change followed by an increasing trend.
Figure 7. Number of correct, incorrect and pass responses for Kit and Dianne for the basic SAFMEDS.
Figure 8. Number of correct, incorrect and pass responses for Kit and Dianne for the Sprints supplemental SAFMEDS procedure.
Figure 9. Number of correct, incorrect and pass responses for Myra and Kylie for the basic SAFMEDS procedure.
Figure 10. Number of correct, incorrect and pass responses for Myra and Kylie for the Sprints supplemental SAFMEDS procedure.
Figure 11. Number of correct, incorrect and pass responses for Nathan, Sarah and Lacy for the basic SAFMEDS procedure.
Figure 12. Number of correct, incorrect and pass responses for Nathan, Sarah and Lacy for the Incremental Sprints supplemental SAFMEDS procedure.
DISCUSSION

SAFMEDS is an assessment and instructional strategy based upon PT principles (Eshleman, 2000a; Graf & Auman, 2005). The name suggests a standard application for use, but a literature review suggests vague and varied applications of the procedure. The purpose of this study was to define a basic SAFMEDS procedure, along with four supplementary procedures, and to determine the effects of procedure on correct, incorrect and pass responses. A review of the data suggests the basic SAFMEDS procedure, as defined above, does not lead to a large increase in correct responding for college students studying Chinese characters and Russian words. This finding is somewhat difficult to interpret in relation to previous findings because many previous research projects have vague definitions of the SAFMEDS procedure (see Quigley, Peterson & Frieder, in preparation) or include what this researcher defined as supplementary procedures (e.g., additional timings). Another reason this finding is difficult to interpret is because SAFMEDS has been described as an assessment and instructional procedure. Previous literature is unclear if the use of SAFMEDS was strictly for assessment of learning or as part of the overall instruction. It is feasible the components of SAFMEDS are differentially needed when applied as an assessment as opposed to instruction.

The results specific to the basic SAFMEDS procedure are important because proponents of SAFMEDS suggest fluent responding should develop with just the basic procedure. Specifically, if Lindsley’s (1996) description of the SAFMEDS acronym is taken literally, studying beyond a one-minute period is an “error.” Previous publications (i.e., Eshleman, 2000a,b; Graf & Auman, 2005) suggest any procedure that adds practice to the 1-min timing is supplemental. A review of previous research seems to suggest it is
the norm as opposed to supplemental (Quigley, Peterson & Frieder, in preparation). However, the 1-min timing recommendation needs to be considered in light of the absence of any additional instruction. Typically, students are receiving additional instruction outside of the 1-min timings, which provides additional learning opportunities. Participants in this study did not receive any further instruction outside of the 1-min timings.

Given the lack of progress the participants in this study made with the basic SAFMEDS procedures in the absence of additional practice, it would seem that the basic procedural guidelines should be altered to include the supplementary practice as a necessary component of fluency development. This suggestion should be considered tentative at this point though given that this study represents the first demonstration of this relation between SAFMEDS and fluency and given the previous distinction between SAFMEDS as an assessment strategy and instructional strategy. Further research should evaluate the basic SAFMEDS procedure in conjunction with other instructional opportunities (e.g., lecture, book reading) to determine if these types of non-fluency-based instructional methods alter performance in the basic SAFMEDS procedure.

A second conclusion drawn from this project is the benefit of the four supplemental SAFMEDS procedures. The whole deck, incremental whole deck, sprints and incremental sprints procedures all showed an improvement in correct responding for all participants, but one. The change in level and trend when each of the supplemental procedures was introduced was promising when compared with performance during the basic SAFMEDS procedure. This conclusion is strengthened given the replication of the level and trend changes across participants and procedures only when the supplemental
procedures were introduced. Additionally, the counter balancing of Chinese and Russian decks across interventions suggests the effects were not a result of the content being learned.

A review of each of the supplementary procedures indicates the incremental whole deck and incremental sprints procedures had the most impact on performance. This is evidenced by larger changes in levels and steeper increasing trends. Comparisons of the two incremental procedures indicate similar increasing trends, but the incremental whole deck led to quicker acquisition (i.e., abrupt upward level change). This finding is interesting given the rationale by Lindsley (1996) for his acronym choice. Specifically, “All,” “Fast,” and “Minute” were chosen to indicate limitations of previous flashcard methods. “All” and “Fast” indicated a need to review “All” material at once instead of in smaller chunks (e.g., learning all 75 cards instead of 25 at a time) and to do so in a manner that would prevent slow, accurate responding with the later need to develop fluency. Results of the current study suggest reviewing the cards in small amounts (i.e., 15 at a time) in a relatively slow manner (i.e., 10-min period) with subsequent 1-min timings led to quick acquisition and steep increases in fluency.

An anecdotal review of the incremental whole-deck procedure suggests some complications with these conclusions however. Participants were not required to use the full 10-min allotted for study. Often, the time participants used to study decreased with each subsequent day. Additionally, participants studied the cards in a “fast” manner during the review period. Specifically, participants would study the cards in a similar format to the timing procedure. Lastly, the participants would often utilize a study procedure similar to error correction procedures (e.g., additional practice for errors)
utilized in other projects (e.g., Hughes, Beverly & Whitehead, 2007). This anecdotal information suggests that perhaps participants were using a practice procedure that satisfied the “fast” and “minute” components of SAFMEDS.

The final conclusion drawn from this project is the need for further SAFMEDS research. As stated elsewhere (Quigley, Peterson & Frieder, in preparation), these authors believe the refining of the SAFMEDS procedure is only the beginning of needed SAFMEDS research. As stated above, further replication of these results is warranted before more firm conclusions can be drawn. Replications could focus on further comparisons of the supplemental procedures to determine if one procedure leads to quicker fluency development. Replication with different material, populations and learning channels is also warranted to determine if these effects hold across other variables. Beyond these areas of future research, there is a large need for researchers to parcel out the role of practice effects and reinforcement rate, if any, with SAFMEDS.

Doughty, Chase and O’Shields (2004) provide an in-depth discussion of the potential for practice effects, rate of reinforcement and fluency building practices. These conclusions, although specific to SAFMEDS, align with Binder’s (1996) call for further research for fluency-based instruction in general.

This research should be interpreted with some caution due to limitations. First, participants did not complete the basic procedure as defined above. Specifically, daily timings were not completed because participants did not practice on weekends. It is reasonable to assume that participants would have had a higher number of corrects with the additional learning trials afforded through true daily practice. The lack of daily timings was a trade-off in this project with the desire to control access to the decks to
prevent additional study outside of the timings. Another limitation was not letting participants continue with a deck until rates of performance stabilized. This limitation is critical for the incremental procedures. If participants were able to continue until higher rates of responding were observed the typical decrease in correct responses when introducing the entire deck might have been reduced. Another possible limitation is the participants within this study. Most participants had multiple years of experience with a second language, were high performing college students (i.e., > 3.0 grade point average) and had used SAFMEDS prior to enrolling in the study. It is unknown if controlling for these variables would alter participant performance.

Perhaps another limitation is the lack of counterbalancing for the order participants completed timings with the different decks across phases. A lack of counterbalancing might have provided additional instructional effect. For example, if participants repeatedly completed the Chinese deck timing after the Russian deck timing, performance could have been higher on the Chinese deck because of the warm up provided by the Russian deck timing. If this phenomenon was observed it would be especially problematic after the supplementary procedures were introduced because the phenomenon might have partially accounted for the results. To address this possible limitation, the order of timings for each participant across each phase was reviewed. Order was classified as balanced (i.e., either deck was timed first between 40-60% of the time) or unbalanced (i.e., either deck was timed first greater than 60% of opportunities). When both decks were exposed to the basic SAFMEDS procedure, 10/14 participants (i.e., Karly, Terry, Louise, Dianne, Kit, Jackson, Nathan, Lacy, Jenna, and Myra) had a balanced order. A comparison of level and trends across participants with a balanced
order and between participants with an unbalanced order suggested similar performance, thereby indicating no warm up effects. When a supplemental SAFMEDS procedure was introduced, 9/14 participants (i.e., Louise, Terri, Dianne, Jackson, Bailey, Nathan, Sarah, and Kylie) had an unbalanced order where the deck continuing with the basic procedure was timed first followed by the supplemental deck. However, comparisons of level and trends across participants with and without balanced order indicated similar performances regardless of order. The only exception to this is Myra. Based upon this information it is believed the order effects are minimal, if present at all.

In summary, the basic SAFMEDS procedure defined in this project did not appear to facilitate fluency development with Chinese characters and Russian words with college students. When participants used a supplementary procedure in conjunction with the basic procedure an increase in correct responses per 1-min timing was observed. Participants using the incremental whole deck supplementary procedure had the quickest acquisition and steepest increasing trends.
REFERENCES


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Appendix A

Literature Review Manuscript
A Review of SAFMEDS: Evidence for Procedures, Outcomes and Future Research

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Abstract

SAFMEDS is an assessment and instructional strategy pioneered in the late 1970’s by Ogden Lindsley (Calkin, 2003; Graf & Auman, 2005; Potts, Eshleman & Cooper, 1993). SAFMEDS was developed as an extension and improvement of flashcards. The purpose of this article is to provide an overview of the literature related to SAFMEDS and to identify further research needs. The results of this review suggest a great deal of research is still needed to clarify the SAFMEDS procedures and the benefits of SAFMEDS over traditional instruction. These conclusions are in line with broader criticisms of fluency-based instruction (Binder, 1996; Cooper, 2005; Doughty, Chase & O’Shields, 2004).

Keywords: SAFMEDS, flashcards, fluency, precision teaching
A Review of SAFMEDS: Evidence for Procedures, Outcomes and Future Research

Lindsley (1992) described precision teaching (PT) as a method for making educational decisions based upon changes in learner performance. West, Young, and Spooner (1990) described PT as a precise and systematic method of evaluating instruction. Measurement of performance is a clear hallmark of PT, and this measurement most often consists of timed probes to evaluate learner performance on specific skills. For example, students might be required to complete a number of multiplication facts or read a passage within a specified time limit. The number of correct and incorrect multiplication facts or words read is then charted, and teachers use this information to evaluate student performance and determine future instructional needs. The timed probes can also serve as instructional opportunities themselves, especially if they are conducted repeatedly, because the learner is exposed to the instructional material multiple times.

One particular procedure PT-style intervention that is often used for instruction and assessment is referred to as say-all-fast-minute-every-day-shuffled (SAFMEDS). SAFMEDS emerged in the late 1970’s and early 1980’s from the work of Ogden Lindsley (Calkin, 2003; Graf & Auman, 2005; Potts, Eshleman & Cooper, 1993). Lindsley (1996a) began requiring the use of flashcards by students in his graduate classes in the fall of 1978. SAFMEDS typically focuses upon “seeing” the stimulus, which is most often a flashcard, and “saying” a response. This is typically referred to as a see/say learning channel. A learning channel is the specification of the sensory dimensions of the stimulus and the topographical dimension of the response (e.g., see/say; Johnson & Layng, 1996). The learning channels utilized within SAFMEDS can be altered (e.g., see/write, hear/say, see/sort), but they are most commonly see/say.
Lindsley (1996a) differentiated his SAFMEDS procedure from typical “flashcard” procedures in several ways. Specifically, Lindsley stated students needed to “Say” aloud the answers to their flashcards, indicating that the typical flashcard procedure of silent card viewing was not effective. He suggested students would benefit from viewing “All” the cards to prevent learning small portions of the material at a time. Accuracy was not enough, and students were told they needed to say the cards “Fast.” He wanted students to avoid starting practice by being slow and accurate and then trying to build speed later. He wanted students to only practice for “a Minute.” He thought practice should be brief rather than for long periods of time. Lindsley also wanted students to practice “Every Day” so that practice was distributed over time. Finally, he wanted the cards “Shuffled” before each practice to prevent serial learning. Thus, this specific combination of strategies became known as SAFMEDS.

Graf and Auman (2005) reiterated the distinction between SAFMEDS and flashcards and provided additional discussion of each of these factors, as well as rules and tips for SAFMEDS use. Their procedures suggest that learners should hold their own deck of cards to promote responses at the learner’s own pace. They suggested learners should not be allowed to make additional markings on the cards. This suggestion was to avoid stimulus control issues, such as the extraneous marks on the card cuing correct answers rather than the text on the card. The learners should also turn the card over after a response to check their answers against the answer on the back of the card. The authors also stated that practicing with multiple decks can help promote generalization. Eshleman (2000a,b) also provides similar instructions regarding SAFMEDS.
Taking Lindsley’s (1996a), Eshleman’s (2000a,b), and Graf and Auman’s (2005) procedures together, a basic SAFMEDS procedure could be summarized as the following. The learner:

1) Holds the complete deck,

2) **Shuffles** the cards,

3) Starts the timer for **1 minute**, 

4) As **fast** as possible, “**Sees**” front and out loud “**says**” the information on the back of the card,

5) Turns the card over and checks answer to determine answer correctness,

6) Sorts correct and incorrect responses into piles,

7) After the time expires, counts the number of responses per pile,

8) Charts performance for review and instructional changes, and

9) Repeats **daily**.

Based upon the needs of the learner, “tweaks” to the basic procedure and additional practice may be necessary to build fluency. Dependent upon the needs of the learner changes can be made to one or multiple steps. For example, someone might assist a learner by manipulating the deck for them to increase fluency (Kubina, Ward & Mozzoni, 2000), a learner might use a deck without all of the cards to provide more learning opportunities (e.g., Kim, Carr, & Templeton, 2001), a learner might vary the timing duration (e.g., 30-seconds instead of 1-minute; Meindl et al., 2013), a learner might conduct multiple timings within a day (e.g., Nam & Spruill, 2005), or the learner might use additional error correction procedures to facilitate increased fluency (Beverly, Hughes & Hastings, 2009).
In line with other fluency-based instructional methods, SAFMEDS is proposed to have multiple benefits beyond traditional approaches to learning that focus solely on accuracy (e.g., Graf & Auman, 2005). Haughton (1980, 1981) proposed the benefits of fluency-based instruction could be captured by the acronym REAPS, which represents Retention, Endurance, and Application of Performance Standards. (See Merbitz, Vieitez, Merbitz & Binder [2004] for a slightly different acronym but with similar outcomes). Building fluency in academic tasks is thought to promote retention, a measure of performance over time without practice. For example, if students in an introductory psychology course master psychology principles during a college course, and they also demonstrate mastery after a summer break with no practice, then retention is said to have occurred. Haughton (1980, 1981) suggests that retention is more likely to occur if the skills were originally mastered to a certain fluency level than if skills were only mastered for accuracy. Building fluency is also thought to promote endurance. Endurance is performance that is resistant to distractions and can be performed for long durations. Finally, fluency is also thought to promote the application of performance to other tasks. For example, if one is fluent on basic math facts, this will promote better success on more difficult math problems in the future.

The purpose of this literature review was to provide readers with a review of SAFMEDS literature to summarize the ways in which SAFMEDS have been implemented in the literature and to determine areas of research that need to be conducted to further refine the procedures and to identify the level of evidence supporting the claims that fluency building’s importance in skill development. The specific questions that were addressed are:
1) What does the literature indicate regarding the effectiveness of the basic SAFMEDS procedure (as outlined above)?

2) What does the literature indicate regarding various alterations to the basic SAFMEDS procedure and the effectiveness of those alterations?

3) What does the literature indicate regarding the proposed outcomes of SAFMEDS (i.e., REAPS)?

4) Under what conditions and with what learner populations has SAFMEDS been evaluated?

**Methods**

**Search Methods**

The scientific literature base for SAFMEDS was determined using three processes. First, the terms “SAFMEDS,” “SAFMEDS and fluency,” “SAFMEDS and precision teaching,” and “SAFMEDS and flashcards” were used to perform electronic database searches. The databases searched were PsycInfo and ERIC. Additionally, the same terms were used to search in Google Scholar ([http://scholar.google.com/](http://scholar.google.com/)). Second, based upon the results of those searches, a reverse author search was utilized. Specifically, the researcher reviewed the citations in each paper identified in the PsychINFO, ERIC, and Google Scholar searches to find additional relevant publications that did not appear in the electronic database searches. Third, a review of on-line archives of the Association of Behavior Analysis International (ABAI) conference presentations (i.e., annual, international, autism and other) from 2001 to 2013 was conducted by searching “SAFMEDS” and “flashcards” as key terms. Finally, a request
for SAFMEDS references was posted to a PT and behavior analysis listserv. Articles had to contain the term “SAFMEDS” for further review.

It is recognized that a potential limitation of this search method is the exclusion of articles using a SAFMEDS procedure but referring to it by another name (e.g., flashcards). Although other singular terms (e.g., “flashcards”) might have revealed further references there were two major barriers to inclusion. First, the number of hits that resulted from “self-study” and “flashcards” were far too numerous for review (i.e., hundreds to thousands across multiple search engines). Second, without the inclusion of the terms “SAFMEDS” it becomes more difficult to be sure the “flashcard” procedures were at least based upon the basic ideas presented by Lindsley (1996a), Eshleman (2000a,b) and Graf and Auman (2005). Therefore, only articles that contained the term “SAFMEDS” were kept for further review.

**Review Methods**

All articles were selected, reviewed, and scored for based on specific criteria. These criteria are identified and defined below.

*Conceptual/data-based distinction.* All articles identified based upon the initial search criteria were categorized as either conceptual or data-based articles. Conceptual articles were SAFMEDS articles that discussed SAFMEDS in some manner but did not include any empirical data in relation to SAFMEDS as an independent variable. Data-based SAFMEDS articles were those where SAFMEDS was an independent variable and empirical data that measured the effects of SAFMEDS were provided. Conceptual articles were not reviewed further but are listed in the expanded bibliography in Appendix A.
**Peer-review.** Data-based articles were further reviewed to determine whether the reported data had been peer-reviewed prior to being made public (e.g., published in a journal, online, conference presentation). An article was considered peer-reviewed if it was published via a journal requiring independent reviewers to determine merit prior to publication. The criticisms of the peer-review process are a recognized limitation (e.g., Lee, Sugimoto, Zhang & Cronin, 2013; Peters & Ceci, 1982). However, regardless of the criticisms, it is the process utilized for determination of merit and therefore only peer-reviewed published articles are reviewed here. Articles that were data-based but not peer-reviewed, were not reviewed here but are listed in the expanded bibliography in Appendix A.

**Specific article/study characteristics.** Each remaining article was reviewed for information specific to nine domains: 1) purpose of the study, 2) research design, 3) the content of SAFMEDS and the learning channel, 4) population, 5) adherence to the basic SAFMEDS procedure, 6) supplemental SAFMEDS procedures (e.g., practice prior to timing), 7) whether or not the procedures were altered based upon learner performance, 8) REAPS and 9) practice effects. These nine components were chosen because of their potential in providing data to address the purposes of this literature review. Specifically, in order to judge the effectiveness of the basic SAFMEDS procedure and alternative SAFMEDS procedures, the procedures themselves and learner performance across conditions must be documented. Domains 5, 6 and 7 were included to provide this information. Although a SAFMEDS procedure might indicate an increase in fluency, the specific outcomes of fluency (i.e., REAPS) also must be explicitly examined. Domain 8 was included to provide this information. Domains 1, 3, and 4 were included to provide
information regarding the conditions and populations with which SAFMEDS has been implemented. Domains 2 and 9 were included to provide information to assess general criticisms of fluency-based instruction by Binder (1996) and Doughty, Chase and O’Shields (2004; i.e., research design concerns and control of specific confounding variables). Each of these domains are described in more detail below.

Research design is reported as “Between-subject,” “Within-subject,” or “Mixed.” A between-subject design was noted when the combined performance of participants within a control condition were compared to the combined performance of the same or different participants in an experimental condition (Johnston & Pennypacker, 2009). A within-subject design was noted when individual performance of participants was compared across control and experimental conditions. If the within-subject design was noted, it was further specified as either baseline logic or behavioral dynamics. This distinction is important in the PT literature and specifies different goals of measurement. According to Cooper (2005) and Kubina (2012), baseline logic designs seek steady state responding across all conditions to determine functional relationships, whereas behavior dynamics searches for transitory states of behavior across conditions to determine predictable patterns of behavior at the correlational level (see Marr, 1992 for further discussion regarding this distinction). Baseline logic was noted when learner’s performance was evaluated using a commonly accepted within-subject experimental design (i.e., reversal/withdrawal, multiple baseline, changing criterion, or multiple treatment). Visual representation of performance across control and experimental conditions, such as a graph of learner performance, was required for the study to be categorized as baseline logic. Behavioral dynamics was noted when change in learner
performance was presented on a Standard Celeration chart and did not include a standard within-subject research design. If the design included only intervention data or only baseline and intervention data, with no further experimental manipulation of the independent variable, but data were presented on a standard celebration chart, the article was coded as behavioral dynamics design. In some cases, multiple designs were used. Therefore, mixed design was noted if multiple analyses (between-subject, within-subject/baseline logic, and behavior dynamics) were included in the manuscript. For example, Kim, Carr, and Templeton (2001) evaluated learner’s ability to maintain fluent rates of performance in the face of distractions and over longer periods of time (i.e., 20-minutes). Changes in performance were documented using a standard celeration chart but were replicated within a reversal design. This article was noted as “Mixed – baseline logic/behavioral dynamic” for satisfying both criteria.

*Adherence to the basic SAFMEDS procedure* described in the introduction of this article was also evaluated. If SAFMEDS procedure in the study used the general steps described above, this was noted. *Supplemental SAFMEDS* was scored to document any additional procedures researchers might have included with the basic SAFMEDS procedure. *Alteration to the SAFMEDS procedure* was scored to determine if the researchers changed the SAFMEDS procedure based upon learner performance. The documentation of procedural changes is important when evaluating a specific procedure. Adherence to the basic SAFMEDS procedure, supplementary SAFMEDS procedures, and alteration of SAFMEDS procedures were each reported as “Yes,” “No,” or “Unknown.” Adherence to the basic SAFMEDS procedure was marked as “Yes” if the authors used a SAFMEDS procedure that matched the nine basic steps described above.
All nine components had to be described for “Yes” to be scored. “No” was scored if there was any description of the SAFMEDS procedures that deviated from the basic SAFMEDS procedure. “Unknown” was scored if there was not sufficient information to determine what the specific SAFMED steps were. The use of supplementary SAFMEDS procedures was scored as “Yes” if any additional components beyond the basic nine steps described above were utilized. The additional components were noted. An indication of “No” was scored if there were no additional steps beyond the basic nine. An indication of “Unknown” was scored if there was not sufficient information to answer the question.

Alteration of SAFMEDS was scored “Yes” if the authors described changes to the SAFMEDS procedures they made based upon learner performance. The alteration(s) of procedures were noted if they were described. An indication of “No” was scored if the SAFMEDS procedures were not changed during the study. An indication of “Unknown” was provided if there was not sufficient information to answer the question.

REAPS and practice effects were scored as “Yes” or “No.” REAPS was scored as “Yes” if at least one purpose of the study was to directly evaluate one of the proposed outcomes of SAFMEDS. That is, the experimental arrangement had to be a condition which would directly assess one component of REAPS (retention, endurance, or application of…). An indication of “No” was scored if there was not at least one experimental arrangement with the purpose of assessing one component of REAPS.

Practice effects is a broad label referring to the critique some researchers have made about PT procedures. Specifically, Doughty, Chase, and O’Shields (2004) have suggested that much of the fluency-building research has not controlled for the confounding variables of multiple practice opportunities (i.e., number of exposures to the...
stimuli) and rate of reinforcement. Thus, we wanted to determine if the studies found controlled for these effects. Practice effects were scored as “Yes” if the authors utilized procedures that controlled for practice opportunities (e.g., yoking of exposure to stimuli between fluency conditions and accuracy only conditions) or reinforcement rate (e.g., time-based schedule as opposed to ratio-based). An indication of “No” was scored if there were no procedures controlling for practice opportunities and reinforcement rate.

Results

Article Identification Results

A total of 53 SAFMEDS references were identified. Of the 53 total references, 14 were classified as conceptual (i.e., Becker, McLaughlin, Weber & Gower, 2009; Binder, 1996; Calkin, 2003; Eshleman 2000a,b; Graf & Auman, 2005; Heward, 2013; Hudson, Knight & Collins, 2012; Lindsley, 1993, 1996a,b; Potts, Eshleman & Cooper, 1993; Stump et al., 1992; Tincani, 2004). The remaining 39 articles were classified as data-based. Of the 39 data-based articles, 12 were classified as non peer-reviewed (i.e., Baird & Stein, 2013; Breeden, 2011; Fox & Ross, 2013; George, 2010; Kelly, & Al Haddad, 2013; Lin & Liu, 2009; Lin, & Ying-Hsiu, 2009; Lorbeer, 2007; Miller, Garner, Jimenez & Neef, 2012; Miller et al., 2012; Tucci, Johnson, & Suggitt, 2013; Xiuyan, 2009). The remaining 27 articles fit the data-based and peer-reviewed criteria and were reviewed based upon the 9 domains described above.

Peer-reviewed, Data-based Article Review Results

Information specific to the nine domains for each article is summarized in Table 1. The purpose of research across the 27 articles varied but had a general theme of increasing a specific behavior(s) in an applied setting. In fact, 23 of the 27 studies
Table 1

Description of factors related to SAFMEDS research

<table>
<thead>
<tr>
<th>Author, Year</th>
<th>Research Purpose</th>
<th>Population</th>
<th>Content / Learning Channel</th>
<th>Research Design</th>
<th>Basic SAFMEDS Procedure</th>
<th>Supplemental SAFMEDS Procedure</th>
<th>Alteration of SAFMEDS Procedures</th>
<th>REAPS</th>
<th>Practice effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beverly, Hughes, &amp; Hastings (2009)</td>
<td>Evaluation of SAFMEDS to build high frequency performance with basis statistic facts</td>
<td>Undergraduate students</td>
<td>Statistics terms / see - say</td>
<td>Mixed; Between &amp; within</td>
<td>No</td>
<td>Yes; multiple daily timings</td>
<td>Yes; e.g., number of timings, error correction</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Bolich &amp; Sweeney (1996)</td>
<td>Development of fluency with Hebrew</td>
<td>11-year-old female</td>
<td>Hebrew sight words / see - say</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; multiple daily timings and pre timing practice</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Bower &amp; Orgel (1980)</td>
<td>Evaluation of errors on performance</td>
<td>Undergraduate students</td>
<td>Education and psychology facts / see - say</td>
<td>Within; Behavioral dynamics</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Byrnes, et al., (1990)</td>
<td>Evaluation of SAFMEDS for preparation of test taking development of fluency with Russian</td>
<td>4 secondary-age students with learning disabilities</td>
<td>Government facts / see - say</td>
<td>Within; Baseline logic</td>
<td>No</td>
<td>Yes; pre timing practice and 2-min timings</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Calkin (1996)</td>
<td>Increase fluency of math facts</td>
<td>Adult female</td>
<td>Russian words / see - say</td>
<td>Within; Behavioral dynamics</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Casey et al., (2003)</td>
<td>Increase fluency of math facts</td>
<td>Elementary students with learning disabilities</td>
<td>Math facts / see - say</td>
<td>Unknown</td>
<td>No</td>
<td>Yes; pre timing practice</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Author, Year</td>
<td>Research Purpose</td>
<td>Population</td>
<td>Content / Learning Channel</td>
<td>Research Design</td>
<td>Basic SAFMEDS Procedure</td>
<td>Supplemental SAFMEDS Procedure</td>
<td>Alteration of SAFMEDS Procedures</td>
<td>REAPS</td>
<td>Practice Effects</td>
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<tr>
<td>Chapman, Ewing, &amp; Mozzoni (2005)</td>
<td>Application of precision teaching with individuals with an acquired brain injury</td>
<td>Five participants between 11 and 19 years of age 6th grade science students</td>
<td>Math facts and orientation facts / Unknown</td>
<td>Mixed; Baseline logic &amp; behavioral dynamics</td>
<td>Unknown (computer-based)</td>
<td>Unknown</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Clorfiene et al., (1998)</td>
<td>Teaching taxonomy via SAFMEDS</td>
<td>66-year-old female</td>
<td>Taxonomy / see – say</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; practice outside of timings</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cobane &amp; Keenan (2002)</td>
<td>Self-management of positive and negative thoughts</td>
<td>8-year-old male with a learning disability</td>
<td>Positive and negative thoughts / see – say</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; multiple daily timings</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cunningham, McLaughlin, &amp; Weber (2012)</td>
<td>Evaluation of SAFMEDS and verbal prompts on fluency</td>
<td>Undergraduate students</td>
<td>Math facts / see – say</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; practice outside of timings</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Eaton &amp; Fox (1983)</td>
<td>Using precision teaching methods in college courses</td>
<td>Undergraduate students</td>
<td>Precision teaching facts / see – say and see – mark</td>
<td>Within; Behavioral dynamics</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Eshleman (1985)</td>
<td>Evaluation of SAFMEDS</td>
<td>Undergraduate students</td>
<td>Various facts / see – say</td>
<td>Within; Behavioral dynamics</td>
<td>Unknown but it was implied</td>
<td>Unknown</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Fox &amp; Ghezzi (2003)</td>
<td>Comparison of fluency techniques and practice effects</td>
<td>Undergraduate students</td>
<td>Logical fallacies / see – click</td>
<td>Between</td>
<td>Unknown (computer-based)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hartnedy, Mozzoni &amp; Fahoum (2005)</td>
<td>Application of precision teaching to the neuropsychiatric population</td>
<td>2 male children; 8 and 10 years of age</td>
<td>Math facts / see – say</td>
<td>Within; Baseline logic</td>
<td>No; teacher directed as opposed to student directed</td>
<td>Yes; pre timing practice and error correction</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Author, Year</td>
<td>Research Purpose</td>
<td>Population</td>
<td>Content / Learning Channel</td>
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<tr>
<td>Hughes, Beverly, &amp; Whitehead (2007)</td>
<td>Evaluation of precision teaching on word reading frequency</td>
<td>7 children; ages 11 &amp; 12</td>
<td>Sight words / see–say</td>
<td>Within; Behavioral dynamics</td>
<td>Unknown but it was implied</td>
<td>Yes; error correction procedures</td>
<td>Yes; timing length</td>
<td>Yes; retention, endurance, stability and application</td>
<td>No</td>
</tr>
<tr>
<td>Kim, Carr, &amp; Templeton (2001)</td>
<td>Evaluation of fluency building on endurance and stability</td>
<td>3 undergraduate females</td>
<td>Hindi characters / see–say</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; multiple daily timings, reduced decks and partial deck</td>
<td>No</td>
<td>Yes; endurance / stability</td>
<td>No</td>
</tr>
<tr>
<td>Korinek &amp; Wolking (1984)</td>
<td>Comparison of study methods</td>
<td>Female graduate student</td>
<td>Observational learning facts / see–say</td>
<td>Within; Behavioral dynamics</td>
<td>Unknown</td>
<td>Yes; additional study time outside of the timings</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Kubina, Ward, &amp; Mozzoni (2000)</td>
<td>Application of precision teaching with a person with a traumatic brain injury</td>
<td>44-year-old male</td>
<td>Answers to anterograde and retrograde questions / see–say</td>
<td>Mixed; Behavioral dynamics &amp; baseline logic</td>
<td>No</td>
<td>Yes; multiple daily timings</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>McDade &amp; Olander (1990)</td>
<td>Comparison of three methods for creating SAFMEDS</td>
<td>Undergraduate students</td>
<td>Psychology facts / see–say</td>
<td>Between</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>McDade, Austin, &amp; Olander (1985)</td>
<td>Comparison of SAFMEDS and computer testing</td>
<td>Undergraduate students</td>
<td>Psychology facts / see–say</td>
<td>Between</td>
<td>No</td>
<td>Yes; pre timing practice</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Meindl et al., (2013)</td>
<td>Evaluation of stimulus control/stimulus generalization</td>
<td>Graduate and undergraduate students</td>
<td>Course relevant material / see–say</td>
<td>Mixed; Within &amp; between</td>
<td>No</td>
<td>Yes; pre timing practice, time, &amp; multiple timings</td>
<td>Unknown</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Author, Year</td>
<td>Research Purpose</td>
<td>Population</td>
<td>Content / Learning Channel</td>
<td>Research Design</td>
<td>Basic SAFMEDS Procedure</td>
<td>Supplemental SAFMEDS Procedure</td>
<td>Alteration of SAFMEDS Procedures</td>
<td>REAPS</td>
<td>Practice Effects</td>
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<tr>
<td>Nam &amp; Spruill (2005)</td>
<td>Evaluation of generalization across learning channels</td>
<td>3 children; ages 10-12 with special needs</td>
<td>Math facts / see – say; hear – say; see – write</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; multiple timings</td>
<td>Unknown</td>
<td>Yes; retention and application</td>
<td>No</td>
</tr>
<tr>
<td>Otander et al., (1986)</td>
<td>Retention of learned information</td>
<td>Undergraduate students</td>
<td>Biology concepts / see – say</td>
<td>Between</td>
<td>No</td>
<td>Yes; pre timing practice</td>
<td>Unknown</td>
<td>Yes; application</td>
<td>No</td>
</tr>
<tr>
<td>Potson, Grabavac, &amp; Parsons (1997)</td>
<td>Evaluation of stimulus equivalence via computer-based SAFMEDS</td>
<td>Undergraduate students</td>
<td>French words / see - type</td>
<td>Unknown (computer-based SAFMEDS)</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes; application</td>
<td>No</td>
</tr>
<tr>
<td>Ragnarsdottir (2007)</td>
<td>Teaching reading via precision teaching and direct instruction</td>
<td>8-year-old with autism</td>
<td>Letters, sounds and words / multiple channels</td>
<td>Within; Behavioral dynamics</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Stockwell &amp; Eshelman (2010)</td>
<td>Teaching terms via SAFMEDS</td>
<td>Female graduate student</td>
<td>Terms / see – say</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; pre timing practice and multiple timings</td>
<td>Unknown</td>
<td>Yes; retention</td>
<td>No</td>
</tr>
<tr>
<td>Togade, Ormandy &amp; Stockwell (2012-2013)</td>
<td>Teaching Tagalog via SAFMEDS</td>
<td>Two graduate students</td>
<td>Tagalog / see – say</td>
<td>Within; Behavioral dynamics</td>
<td>No</td>
<td>Yes; multiple timings, 30-s timing &amp; deck size</td>
<td>Unknown</td>
<td>Yes; retention</td>
<td>No</td>
</tr>
</tbody>
</table>

Note. Only data-based, peer-reviewed SAFMEDS articles are presented here. A complete SAFMEDS bibliography can be found in Appendix A.
attempted to increase fluency with content specific to a need for the participant (e.g.,
material specific to a college course). A see–say learning channel was specified in 23 of
the 27 articles. Six of the 27 articles specified different or additional (some arrangements
utilized more than one channel) learning channels from the see–say. Only one article
specifically addressed potential performance difference between learning channels (i.e.,
Nam & Spruill, 2005). Thirteen of the 27 articles described participants as undergraduate
or graduate students. Ten of the 27 articles described participants as children under the
age of 19. The remaining 3 articles described participants as adults. Ten of the 27 articles
described participants with special needs (e.g., learning disability) or other limiting
impairments (e.g., traumatic brain injury).

Fifteen of the 27 articles utilized a within-subject behavioral dynamics design. Additionally, three articles utilized mixed within-subject designs (i.e., behavioral
dynamics and baseline logic). Given SAFMEDS is based upon PT principles it is not
surprising to see 67% of the articles utilizing a behavioral dynamics design solely or in
combination with a baseline logic design. A within-subject baseline logic design was
utilized four times. Similarly, a between-subjects design was also used four times. Only
one studied examined the relation between the independent and dependent variables via a
combination of between and within-subject designs (i.e., Beverly, Hughes & Hastings,
2009).

Data related to the SAFMEDS procedures suggested varied procedures with little
adherence to the basic procedure. Specifically, 17 of the 27 articles reported SAFMEDS
procedures that did not follow the defined basic SAFMEDS procedures. The remaining
ten articles did not provide enough information to ascertain the SAFMEDS procedure and
were scored as unknown. Supplemental procedures were scored as “Yes” for 18 of the 27 articles and “Unknown” for 9 articles. (None were scored as “No.”) The most frequent addition to the basic SAFMEDS procedure was multiple timings and some form of practice with the cards before the fluency timings. The duration of the fluency timings was consistent across most articles (1 min); however this varied from 30 s to 2 min in three articles. An error correction procedure and partial decks were additional supplemental procedures used. In the 27 studies reviewed, the initial SAFMEDS procedure was altered at least 5 times. SAFMEDS was altered by changing the number of timings, adding an error correction procedure, and by changing the fluency timing duration. Three studies clearly reported no changes to the initial SAFMEDS procedure, whereas in 18 articles it was unclear if changes were made to the initial SAFMEDS procedure or not.

The long-term effects of SAFMEDS (i.e., REAPS) were evaluated in 7 different articles. Each outcome (i.e., retention, endurance, application, performance standards and stability) was assessed at least one time across the 7 different studies. Application and retention were assessed 4 and 3 times, respectively. Nineteen of the articles did not evaluate the long-term outcomes of SAFMEDS. None of the identified literature utilized an experimental arrangement that addressed practice effects and reinforcement rate.

**Discussion**

SAFMEDS is an assessment and instructional strategy pioneered by Lindsley in the 1970’s (Calkin, 2003; Graf & Auman, 2005; Lindsley, 1996a; Potts, Eshleman & Cooper, 1993). Practitioners have been utilizing SAFMEDS for educational and therapeutic purposes ever since its inception. The purpose of this project was to document
the history of SAFMEDS research to provide further information for practitioners when using SAFMEDS and to guide future research. The number of SAFMEDS publications identified (i.e., 53) suggests SAFMEDS has received a fair amount of attention from practitioners and researchers. However, it is noteworthy that only 27 of the identified articles met the criteria for further review and that roughly 50% of the publications related to SAFMEDS are either conceptual in nature or have not undergone the peer-review process. Only 27 articles were empirical evaluations of SAFMEDS that had undergone peer review prior to publication.

Two purposes of this article were to determine the effects of the basic and supplemental SAFMEDS procedures on leaner performance (i.e., research questions one and two). None of the peer-reviewed, empirical articles reported SAFMEDS procedures that followed the basic procedures outlined by Lindsley (1996a), Eshleman (2000a,b) and Graf and Auman (2005). The SAFMEDS procedures utilized across projects generally fit within the basic framework but altered various components (e.g., number of timings). Additionally, some components (e.g., practice and error correction procedures outside of the timings) were added to the procedure. Although all of the articles reported positive results (i.e., increase in desired skills) as a result of using SAFMEDS, it is unclear which component(s) of the SAFMEDS procedure are necessary for success because there is so much variation across studies. Furthermore, in several studies, the procedures were not described clearly enough to determine whether the basic procedures or some variation of them were used. The varied and poorly documented procedures for SAFMEDS across the studies make it difficult to draw conclusions about the effectiveness of the basic and
altered SAFMEDS procedures. It is also unclear what the “standard” procedure for SAFMEDS is.

Doughty, Chase, and O’Shields (2004) conducted a review fluency building procedures. In that review one concern they identified across fluency building procedures (of which SAFMEDS is one) is the lack of clear, consistent operational procedures. The findings of this review indicate that these concerns are valid for SAFMEDS as well. On a practical level, this presents difficulties for practitioners who want to implement SAFMEDS in their classrooms. A clear set of guidelines as to what constitutes the basic SAFMEDS procedure does not seem to exist, nor has it been used consistently enough in the research literature to indicate there is a “standardized” set of procedures. Furthermore, the “tweaks” and adjustments to the basic procedure are quite varied. It is not clear what effects these adjustments to the basic procedure have, when they should be used, and whether they produce more desirable effects on fluency than the basic procedure. Future research on SAFMEDS should seek to provide practitioners with a standard set of evidence-based procedures to follow, as well as meaningful indicators for when adjustments should be made and what those adjustments should be.

A second concern noted by Doughty, Chase, and O’Shields (2004) in their review of fluency building was fluency-based research is limited by the lack of control for the confounding variables of practice and reinforcement rate. The performance gains observed in fluency-building exercises might not be a result of requiring fluency (i.e., timed exercises) but rather the result of the additional practice opportunities fluency-based instruction affords and/or the increased rate of reinforcement experienced during fluency-based instruction. Doughty et al. (2004) identified only three studies (i.e., Evans
& Evans, 1985, Evans, Mercer, & Evans, 1983; Shirley & Pennypacker, 1994) that attempted to separate practice effects and reinforcement rate from fluency-based instruction. Doughty et al. (2004) concluded the results of these three studies provided “unconvincing” support for rate building. This conclusion was based upon the inconsistent and contradictory findings within and between the experiments. In the current review of SAFMEDS literature, all 27 studies reviewed failed to incorporate experimental analyses that could control for practice effects and reinforcement rate. It is clear that this issue has yet to be resolved in the literature and deserves further study.

Another purpose of this review was to determine what the literature indicated regarding the long-term outcomes of SAFMEDS (i.e., REAPS; research question three). Seven articles provided data related to the evaluation of REAPS (Hughes, Beverly & Whitehead, 2007; Kim, Carr & Templeton, 2001; Nam & Spruill, 2005; Olander et al., 1986; Polson, Grabavac & Parsons, 1997; Stockwell & Eshleman, 2010; Togade, Ormandy & Stockwell, 2012-2013). Studies that assessed retention compared performance at one point of time with performance at a later point with no programmed instruction between the assessment dates. Retention tests at 3 weeks (Togade, Ormandy & Stockwell), 7 weeks (Stockwell & Eshleman), 5 to 9 weeks (Hughes, Beverly & Whitehead), and 8 months (Olander et al.) indicated minimal decreases in the rates of correct responses during retention probes, suggesting retention was very high. Only Olander et al. compared the retention of students instructed with SAFMEDS procedures to students instructed with non-fluency building methods. The students who received fluency-based instruction had better retention of skills than the students who received non-fluency-based instruction. This suggests that fluency-building exercises to produce
higher rates of skill retention over time. However, the research is limited by a lack of replication and the concerns noted above such that the generalizability of this conclusion is limited.

Hughes, Beverly and Whitehead (2007) and Kim, Carr and Templeton (2001) assessed endurance and stability. Endurance was assessed by requiring extended timings (i.e., 3 min and 20 min) and measuring the rate of correct responses per minute. Endurance was noted if the learner’s performance remained at levels consistent with 1-min timings throughout the extended timings. Stability was assessed in a similar manner. Instead of altering only the timing duration, distractions such as a radio playing music and additional students making noise were added to the environment. Stability was noted if the learner’s performance remained at previous levels despite the distractions. The data from both studies provided evidence of endurance and stability, suggesting that fluency-building exercises are important for these long-term effects. However, neither study compared these results to non fluency-based instruction methods.

Application was assessed in multiple ways. Hughes, Beverly and Whitehead (2007) provided reading passages with words that were different from the training passages and measured the number of correct and incorrect words read. Nam and Spruill (2005) assessed the application of multiplication facts via tests of different learning channels (i.e., see/say and hear/say) and different visual representations of the math problems (i.e., vertical alignment versus horizontal alignment). Polson, Grabavac and Parsons (1997) tested application by training English to French translation or French to English translation and then presented the words in a reversed fashion to determine if symmetry emerged (see Malott [2008] for an introduction to symmetry and other
equivalence relations). The general findings across the studies indicated when the application test was introduced, performance initially decreased but quickly returned to previous levels. Missing from each project was a comparison of assessment between SAFMEDS and non-fluency based instruction. This, it is unclear whether application would have developed by simply training for accuracy and in the absence of fluency-building exercises. Studies that provide such comparisons could strengthen the position that SAFMEDS leads to better application of learning than traditional instructional approaches. At present, there is not enough data to support such a conclusion.

The final purpose of this review was to provide an overview of conditions and learner populations that SAFMEDS has been evaluated with (i.e., research question four). SAFMEDS was evaluated approximately 47% of the time with undergraduate or graduate students, approximately 37% with children and approximately 11% of time with adults. Gallander, North and Sugar (2001) found that undergraduates were enrolled as participants approximately across 68% of psychological research projects at three different probe dates spanning twenty years (i.e., 1975, 1985 & 1995). The reduced reliance on undergraduate participation is perhaps suggestive of SAFMEDS alignment with PT as an applied science. Although SAFMEDS has been applied across a broader spectrum of individuals, the total number of individuals across the 27 studies that SAFMEDS has been evaluated with is still low. Consideration of the number of participants in light of the varied and unknown procedures across participants further complicates the ability to generalize the findings.

In conclusion, an evaluation of the SAFMEDS data presented here is discussed in relation to general criticisms of fluency-based instruction that have been addressed
elsewhere. Evaluating the application of general criticisms of fluency-based instruction to SAFMEDS (which is only a subset of fluency-based instruction) is important to avoid a logical fallacy. A logical fallacy occurs when an individual assumes something that is true of the whole is also true of its components. For example, if one assumes the statement, “Four is an even number,” is true, and we know 1 and 3 are parts of four, assuming both 1 and 3 are even would be committing logical fallacy. It is possible that individual parts of the whole fit the assumption; however it is not necessarily true. One should not assume it to be true without careful examination first. A method for determining whether the “parts” of fluency-based instruction fit the assumption about the whole of fluency-based instruction is to review the evidence for individual parts. For this reason the SAFMEDS literature was reviewed in light of three general criticisms of fluency-based instruction put forth by other authors.

The first two general criticisms have been introduced above as they related to specific points of the review process and results. Specifically, Doughty, Chase and O’Sheilds (2004) suggested a need for further fluency-based instruction research to control for practice effects and rate of reinforcement. These concerns were discussed above in conjunction with the documentation of SAFMEDS procedures. Cooper (2005) recounted his interaction with a fellow behavior analyst at a conference. The behavior analyst asserted that fluency-based instruction (i.e., precision teaching) lacked “control and is not science” (p. 295). Cooper and subsequently Kubina (2012) have provided a thorough response to these concerns. In short, their response suggested fluency-based research is an applied practice with an emphasis upon behavioral dynamics and not functional relationships. Behavioral dynamics relies upon the logic of replication where
multiple replications suggest a correlation between two variables. As more and more replications of the correlated effect are shown, a stronger inference of a relationship can be made. So, the concern should not be the use of the behavioral dynamics approach, but rather, to what extent the replications suggest a correlational relationship between two variables. Data from this literature review indicate a large reliance upon the behavioral dynamics approach (i.e., 15 of the 27 articles). If there was agreement that this logic was acceptable, there would need to be multiple studies with similar procedures and outcomes in order to draw conclusions about the correlational relationship between SAFMEDS and performance improvement and REAPS. However, as shown here, 15 SAFMEDS articles using the behavioral dynamics approach had multiple variations in research purpose (e.g., language acquisition, education facts, thoughts), population (i.e., children, college-age and older adults with and without disabilities), and SAFMEDS procedures. Thus, it is difficult to apply the strategy of behavioral dynamics as evidence of effect in the case of SAFMEDS. There is a need for systematic expansion and replication of SAFMEDS research to strengthen SAMEDS claims.

Binder (1996) provided the third general criticism of fluency-based instruction. In his review, Binder stated, “Most of [the fluency-based] work has not been documented in the scientific literature, but many of the empirical generalizations derived by fluency researchers and practitioners over the last 30 years suggest opportunities for important systematic research” (p. 164). The outcome of this literature review suggests a fair amount of SAFMEDS literature exists (i.e., 51 total references with 27 references being data-based and peer reviewed). It is difficult to know to what extent this represents the complete literature base for SAFMEDS in order to apply his statement to SAFMEDS.
Personal correspondence with researchers in the field is suggestive that this statement is likely applicable to SAFMEDS though (J. Eshleman, personal communication, July 11, 2013). The second clause of Binder’s statement regarding “opportunities for important systematic research” is applicable to SAFMEDS though. As outlined above there is a need for more research. Perhaps the logical starting point for SAFMEDS research is the SAFMEDS procedure itself. Identifying the parameters of the independent variable would allow for more refined evaluations of associated dependent variables (e.g., REAPS).
References

Using SAFMEDS to increase undergraduate success with statistical concepts.


Pearson.


Additional SAFMEDS References


behavioral concepts to college students: A comparison of flashcards containing examples versus definitions. Paper presented at the Association of Behavior Analysis International Annual Convention, Seattle, WA


Appendix B

Demographics Questionnaire
Participant ID: ________________

1) Highest level of education completed (circle one):

High school  Post high school certification  Less than 2 years of college

Associates Degree  Bachelor Degree  Masters Degree  Doctoral Degree

2) Most recent grade point average: ________________

3) Have you had any training in languages other than your native language?  YES  NO
If YES: What language(s)? ________________________________

Please describe how much and what type of training

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4) Have you ever used SAFMEDS before?  YES  NO
If YES: Please explain

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5) Please list times of availability for conducting research sessions. Sessions will last approximately 15 minutes each.

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<tr>
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<th>Monday</th>
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Appendix C

Social Validity Form
TREATMENT ACCEPTABILITY RATING FORM —Revised (TARF-R)
Thomas Reimers and David Wacker (1988)
Modified by Susan Silvestri (2004) and Renee Van Norman (in progress)

DIRECTIONS:

Please complete the items listed on the following pages of this rating form based upon your experience with the SAFMEDS research. The items should be completed by placing a check mark on the line under the question that best indicates how you feel about the SAFMEDS procedures you experienced.

If you have specific concerns that are not addressed in the rating form or have suggestions to add to the protocol, please use the line under each item to provide the researcher with specific feedback.

You DO NOT need to provide additional feedback on the lines for all items, just those that you have specific comments about.

If a particular question does not apply to you please indicate that you have read the question by writing N/A next to the question.
1. How clear was your understanding of the SAFMEDS procedures?

___ ___ ___ ___ ___ ___ ___ Not at all clear
Neutral ___ ___ ___ Very clear

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. How acceptable did you find the SAFMEDS procedures to be?

___ ___ ___ ___ ___ ___ ___ Not at all acceptable
Neutral ___ ___ ___ Very acceptable

________________________________________________________________________
________________________________________________________________________
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3. How willing are you to implement the SAFMEDS procedures on your own?

___ ___ ___ ___ ___ ___ ___ Not at all willing
Neutral ___ ___ ___ Very willing

________________________________________________________________________
________________________________________________________________________
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4. Do you think cost would prohibit you from implementing the SAFMEDS procedure?

___ ___ ___ ___ ___ ___ ___ No cost
Neutral ___ ___ ___ Cost prohibitive

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

5. Do you think there might be disadvantages in following the SAFMEDS procedure? Please list them in the space below.

___ ___ ___ ___ ___ ___ ___ Not at all likely
Neutral ___ ___ ___ Very likely

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
6. How likely are the SAFMEDS procedures to make a permanent improvement in your learning?

Not at all likely

Neutral

Very likely

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

7. How reasonable did you find the time requirements to be?

Not at all reasonable

Neutral

Very reasonable

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

8. How confident are you the SAFMEDS procedures will be effective for learning different material?

Not at all confident

Neutral

Very confident

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

9. Compared to other learning strategies, how different is the SAFMEDS procedure?

Not at all different

Neutral

Very different

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

10. How disruptive to your current study habits would implementing the SAFMEDS procedures be?

Not at all disruptive

Neutral

Very disruptive

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
11. How effective are the SAFMEDS procedures likely to be for other college courses (e.g., statistics, history, etc.)?

<table>
<thead>
<tr>
<th>Not at all effective</th>
<th>Neutral</th>
<th>Very effective</th>
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12. How affordable are the SAFMEDS procedures?

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<th>Not at all affordable</th>
<th>Neutral</th>
<th>Very affordable</th>
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</table>

13. How much did you like the SAFMEDS procedures?

<table>
<thead>
<tr>
<th>Did not like at all</th>
<th>Neutral</th>
<th>Like it very much</th>
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14. How willing will your friends be to implement the SAFMEDS procedures themselves?

<table>
<thead>
<tr>
<th>Not at all willing</th>
<th>Neutral</th>
<th>Very willing</th>
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15. To what extent are undesirable side effects likely to result from the SAFMEDS procedures?

<table>
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<tr>
<th>Not at all likely</th>
<th>Neutral</th>
<th>Very likely</th>
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16. How much discomfort did you experience as a result of the SAFMEDS procedures?

<table>
<thead>
<tr>
<th>No discomfort</th>
<th>Neutral</th>
<th>Very much discomfort</th>
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17. How willing would you be to change your study habits to implement these procedures?

<table>
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<tr>
<th>No at all</th>
<th>Neutral</th>
<th>Very willing</th>
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18. How well will the SAFMEDS procedures fit into your study routine?

<table>
<thead>
<tr>
<th>No at all</th>
<th>Neutral</th>
<th>Very well</th>
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General Comments

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Appendix D

Examples from SAFMEDS Training Deck
Car

Hen

Dragon Fruit
Appendix E

Russian and Chinese SAFMEDS
<table>
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<tr>
<th>Russian Word</th>
<th>English Word</th>
<th>Chinese Character</th>
<th>Russian Word</th>
<th>English Word</th>
<th>Chinese Character</th>
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<tbody>
<tr>
<td>один</td>
<td>One</td>
<td>一</td>
<td>крыса</td>
<td>Rat</td>
<td>鼠</td>
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<tr>
<td>два</td>
<td>Two</td>
<td>二</td>
<td>овца</td>
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<td>三</td>
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<td>к северу</td>
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<td>вверх</td>
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<td>лед</td>
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<td>Rabbit</td>
<td>兔</td>
<td>снег</td>
<td>Snow</td>
<td>雪</td>
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Appendix F

Sample Data Sheet
**Participant ID:** ________________  **Date of Session:** ____/__/____

**Scored by:** ________________  **Purpose (circle one):**  **Primary**  **IOA**

**Data Summary:**
Total # of correct responses: _______  Total # of incorrect responses: _______  Total # of pass responses: _______

Total # of self-correct responses: _______

**IOA Calculations:**
Agreements _____ / Total responses ____ X 100 = ______ % IOA

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Appendix G

Fidelity Checklist
SAFMEDS Integrity Summary Sheet

Scored by: ___________________________     Date Integrity Scored: 
_____/_____/_____

Participant: ___________________________           Session Date: _____/_____/_____

Scoring (circle one): Primary       IOA

Phase (circle one):

Baseline       Whole-deck non-incremental       Whole-deck Incremental

Non-incremental Sprints       Incremental Sprints

Overall Integrity Score

Number of correct _____ / Number of correct + incorrect = ______X 100 = 
___________ % integrity
1. **Russian Testing Timing:**
   - a. Did the researcher conduct timing for the Russian deck?
   - b. Did the participant shuffle the cards before the timing?
   - c. Was the Russian deck timing 1-min (+/- 2 seconds)?
   - d. Did the participant sort the cards correctly into piles during the timing?
   - e. Did the participant count their responses for each pile following the timing?

2. **Chinese Testing Timing:**
   - a. Did the researcher conduct timing for the Chinese deck?
   - b. Did the participant shuffle the cards before the timing?
   - c. Was the Chinese deck timing 1-min (+/- 2 seconds)?
   - d. Did the participant sort the cards correctly into piles during the timing?
   - e. Did the participant count their responses for each pile following the timing?

### Intervention Administration (ONLY 1 FROM BELOW)

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<thead>
<tr>
<th>Intervention Type</th>
<th>Number correct</th>
<th>Percent</th>
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<tbody>
<tr>
<td>3. Non-incremental whole-deck</td>
<td>1/4</td>
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<tr>
<td>4. Incremental whole-deck</td>
<td>1/4</td>
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<tr>
<td>5. Non-incremental sprints</td>
<td>1/5</td>
<td></td>
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<tr>
<td>6. Incremental sprints</td>
<td>1/5</td>
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Appendix H

HSIRB Approval Letters
Date: August 1, 2013
To: Stephanie Peterson, Principal Investigator
    Shawn Quigley, Student Investigator for dissertation
From: Amy Naugle, Ph.D., Chair
Re: HSIRB Project Number 13-07-27

This letter will serve as confirmation that your research project titled “An Evaluation of Multiple SAFMeds Procedures” has been approved under the expedited category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may only be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study”). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: August 1, 2014
Date: September 30, 2013

To: Stephanie Peterson, Principal Investigator  
   Shawn Quigley, Student Investigator for dissertation

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 13-07-27

This letter will serve as confirmation that the change to your research project titled “An Evaluation of Multiple SAFMEDS Procedures” requested in your memo received September 26, 2013 (to add use of a video in conjunction with the modeling and vocally to describe procedure) has been approved by the Human Subjects Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: August 1, 2014
Date: November 26, 2013

To: Stephanie Peterson, Principal Investigator  
Shawn Quigley, Student Investigator for dissertation  
Anthony Kennedy-Walker, Student Investigator

From: Amy Naugle, Ph.D., Chair

Re: HSRIR Project Number 13-07-27

This letter will serve as confirmation that the changes to your research project titled “An Evaluation of Multiple SAFMEDS Procedures” requested in your memo received November 25, 2013 (to change drawing for two $50 gift cards to giving each participant a $10 gift card upon completion of the study) have been approved by the Human Subjects Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSRIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: August 1, 2014

251 W. Walker Hall, Kalamazoo, MI 49008-5456  
PHONE: (269) 387-8293  FAX: (269) 387-8276