Abstract
Up to 75% of school-age children in the United States are affected by speech sound disorders with approximately 28% of these making no measurable progress in traditional treatment. For these children, alternative approaches are often needed. The current study tests a relatively novel and easy-to-implement approach based on tactile biofeedback using the Speech Buddies ® tool. This case study included two treatment-resistant children aged 5/5 and 10/10 respectively. Through a school-year-long therapy schedule, both students achieved remediation (90% accuracy). Implications for the treatment of residual articulation errors are discussed in depth.

Background
Articulation and speech sound disorders affect as many as 75% of the school-age population (Shimberg & Nakawatzki, 1994) and can negatively impact teacher expectations of students with reduced speech intelligibility (Overy, Carroll & Berrthal, 2007) as well as inter-peer relationships among school-age children (Ruscello, 2012). Even though there is evidence that traditional and phonological approaches to treating speech sound disorders can be effective, Jacoby, Lee, Kummer, Lovin and Creaghead (2002) found that, broadly speaking, treatment employing these methods resulted in no measurable progress for approximately 28% of the 234 pre-school and school-age children they analyzed over a two-year period.

In addition, evidence shows that children who have speech sound disorders that are not remediated by approximately age 9 are at increased risk of developing what are called “residual” speech errors (Shuster, Ruscello & Toth, 1996). These residual errors are particularly resistant to treatment and in many cases may result in a child being exited from therapy for lack of progress. Previous studies have examined the effect that alternatives to traditional approaches to articulation therapy have had on these residual speech sound errors. In general, these studies have examined various sensory biofeedback approaches, which use instrumentation to make covert physiological processes more overt (Huang, Wu & Hsiao, 2006). Examples of sensory biofeedback are electropalatography, ultrasound, spectroscopy and speech feedback. These approaches have varying levels of evidence in remediating these residual errors.

Despite this promise of remediation from many of these approaches, they have had limited use in school-based services, the main service setting for delivery in the United States. This is primarily due to the high cost of these approaches, which often require highly specialized equipment and trained applications. These approaches, therefore, often require extensive training for them to be effectively implemented. The current study aims to investigate the effect of one of these alternative approaches, tactile biofeedback, on speech sound errors. Speech Buddies ® is a form of tactile biofeedback. This approach has varying levels of evidence in remediating these residual errors.

Method
Participants
The author recruited 2 students at Brooks Elementary School in Windsor, California who were enrolled in this study, which was approved by the Institutional Review Board (IRB) at a local community college. The participants were two second grade students who were identified as having difficulty with speech sound production at the beginning of the 2012-2013 school year. These students did not appear to have any neurological or medical condition that might interfere with their performance in the study. The students were selected on the basis of their diagnosis of speech sound disorder, as determined by a speech language pathologist in the Windsor Unified School District.

The second participant, S.L., a fifth grade boy, was ten years, eleven months old at the time of enrollment in the study. S.L. had received extensive speech therapy services since pre-school, which included treatment focused on speech sound production as well as speech related goals. For the time period covering this school year, S.L. only had speech-related goals on his IEP. S.L. had worked on treating misarticulated /r/ during the previous school year (his fourth grade year) with no measurable progress.

Therapy Plan
Participants received twice weekly services of thirty-minute, individual therapy sessions, from the author, a licensed and ASHA-certified speech-language pathologist with over twelve years of clinical experience. The Speech Buddies ® device, which is a speech production instrument specifically designed for the North American English /r/ sound, was used in this study as the primary means to elicit the /r/ sound. The device features a coil which is inserted into the oral cavity, immediately posterior to the upper dentition. Once in place, the participant utilized the Speech Buddies ® set for the remainder of the therapy session.

The Speech Buddy was used as the primary mechanism for cuing in therapy sessions. However, these cues were supported by visual cues, particularly with regard to training the correct, rounded and slightly protruded lingual configuration necessary for correct /r/, particularly consonantal and pre-vocalic /r/. Verbal instructions were also used to support the primary tactile cuing mechanism. For these reasons, the therapy approaches employed here best reflect a modified version of the traditional method of articulation therapy, as described by Van Riper and Emerick (1984).

Assessments
The R Speech Buddy was the primary cuing mechanism throughout the school year, as deemed necessary by the study SLP. Mean therapy hours administered for the two participants were approximately 25 hours at an average rate of one hour per week. All assessment data were gathered by the study SLP. The assessment battery comprised of primarily of the Second Contextual Articulation Test (S-CAT) phoneme-specific probe for both the consonantal and vocalic versions of /r/. The probes assess the accuracy of, in this case, /r/ in all possible phonetic contexts. S-CAT probes were administered on two separate occasions, at least two days apart both at baseline and at the end of the school year. In addition, the Goldman-Fristoe Test of Articulation, 2nd Edition (GFTA-2) was administered at baseline and at the end of the study as a means of comparing participants’ progress with a standardized sample.

Results
Tables 1 and 2 summarize the participants’ performance at baseline and at final assessment of the S-CAT Probes.

Discussion
The results suggest that a remediation response was achieved by both participants across phonetic contexts. S.L. showed some resistance to using the /r/ Speech Buddy /r/ sound and required additional positional adjustments to be able to initially produce the /r/ sound correctly. R.J. showed no such resistance and was quickly stimulable by the /r/ sound in pre-vocalic and vocalic contexts with the Speech Buddy. Additional training was necessary for R.J. to generalize correct /r/ up to the words-in-sentences level.

The post-treatment administration of the GFTA-2 was completed on October 3, 2012. The post-treatment administration of the GFTA-2 was completed on May 16, 2013. Table 3 summarizes the pre- and post-treatment results of the Sounds-in-Words subtest of the GFTA-2.

Table 3 Pre-treatment versus post-treatment performance on the GFTA-2

Pre-Treatment Post-Treatment

<table>
<thead>
<tr>
<th>Participant</th>
<th>Standard Score</th>
<th>Percentile Rank</th>
<th>Standard Score</th>
<th>Percentile Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.L.</td>
<td>66</td>
<td>100</td>
<td>66</td>
<td>100</td>
</tr>
<tr>
<td>R.J.</td>
<td>30</td>
<td>10</td>
<td>75</td>
<td>30</td>
</tr>
</tbody>
</table>

The results of the GFTA-2 suggest that Speech Buddies would be a viable treatment option for children in their later school-age years. Interestingly, both students had received at least one full school year of speech therapy. For these children, alternative approaches are often indicated for such children.

Given that R.J. and S.L. were both older than age 9, their ability to acquire these speech sound errors may become classed as “residual” errors. Preston and Edwards (2007) noted that such errors often co-occur with incomplete phonological representations of the target speech sounds in these pre-adolescents and adolescents.

The study clinician was initially drawn to investigating the clinical effectiveness of Speech Buddies as a viable alternative approach given their lower cost as compared to other sensory biofeedback approaches, such as electropalatography and ultrasound, which are often too expensive for clinic settings. Speech Buddies ® are a viable low-cost, easy-to-implement treatment option for children who have speech sound disorders that are not remediated by traditional approaches to remediation. Nevertheless, further evidence is required to determine whether these results may be applied to a larger participant sample size.