Using Delayed Auditory Feedback to Treat Fluency and Speech Rate Deficits in Individuals with Parkinson’s Disease: Specific Clinical Considerations

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Abstract

The purpose of this second of two related papers is to present detailed clinical applications of delayed auditory feedback (DAF) in treating the speech rate and fluency deficits in speakers with Parkinson’s disease. For optimal results from DAF, clinicians should provide the speaker with instruction, modeling, and feedback. Toward that goal, the contributions of clinician instruction on the effectiveness of DAF will be discussed. In addition, important clinical issues such as choosing effective delay intervals, trade-offs between speech rate and intelligibility, and the “first word dilemma” will be considered.

As discussed in a previous paper (Blanchet, 2006), delayed auditory feedback (DAF) involves delaying the auditory feedback of the person’s speech, requiring her or him to prolong each syllable or word until the feedback “catches up” to the speech production. This task is sometimes referred to as “matching” the delayed signal. Ideally, this induces a relatively slow, fluent speech pattern characterized by prolonged syllable nuclei (i.e., vowels), smooth transitions between syllables, and relatively stable syllable duration (Goldiamond, 1965; Ingham, 1984; Bloodstein, 1995).

In general, findings from a limited number of published studies confirmed clinical impressions of delayed auditory feedback as an effective rate control strategy for some speakers with Parkinson’s disease (e.g., Adams, 1994; Downie, Low, & Lindsay, 1981). Effects on speech intensity and pitch were also reported, although these were not as consistent or as dramatic (Hanson & Metter, 1983). Improvements in rate and intelligibility were apparently related to increased articulation time, as well as increased pause time (Adams, 1994; Yorkston, Beukelman, & Bell, 1988). Studies have generally shown DAF to be most effective in reducing reading rate, as opposed to spontaneous speech rate (e.g., Dagenais, Southwood, & Lee, 1998; Yorkston et al., 1988). This may be due to the reduced linguistic and motor demands of reading (Norris, Healey, Hoffman, Blanchet, Kaufman, & Scott-Trautman, 1998), and is consistent with findings of the effects of DAF on persons who stutter (Bloodstein, 1995; Ingham, 1984).

Delay intervals ranging from 50 ms (e.g., Downie et al., 1981) to 150 ms (e.g., Hanson & Metter, 1983) were used effectively with speakers with dysarthria, while intervals exceeding 150 ms were reported to yield no further gains in rate or intelligibility (Yorkston et al., 1988). In fact, such delays intervals have reportedly produced “disastrous” effects on the speech of some speakers (Dagenais et al., 1998; Rosenbek & LaPointe, 1978). Such reactions to relatively long delay times are commonly
observed during clinical use of DAF, and likely result from improper matching of the delayed signal. For example, a delay interval of 150 ms produces a relatively long time lag between production of a syllable and its perception. Unless the speaker continues to prolong the syllable until the delayed auditory signal is perceived, this signal is not completely "canceled out." This can result in a salient and potentially aversive "echo," which may limit the rate reduction benefits of DAF, as well as elicit syllable repetitions (Goldiamond, 1965; Rosenbek et al., 1978; Dagenais et al., 1998; Black, 1951; Lee, 1951; Soderberg, 1968).

Therefore, to facilitate optimal use of DAF, clinicians should consider providing instruction, modeling, and feedback (Rosenbek et al., 1978; Yorkston et al., 1988). Although the use of clinician feedback has been suggested during speech therapy with motor speech patients (e.g., Duffy, 1995), there is a paucity of studies reporting its use during DAF-based interventions (Blanchet, 2006). As stated previously, DAF has been primarily used with these speakers as a prosthetic device, as carry-over of speech gains is often difficult to achieve (Dagenais et al., 1998). However, it may be difficult for a patient with a degenerative neurological disease to generalize a behavior when he or she is not informed of what that behavior actually is. In other words, simply instructing the patient to wear a DAF unit and "begin talking" does not provide any guidelines for properly matching the delayed signal in order to obtain maximal improvements in speech production.

As highlighted by Duffy (1995), overt instruction improves performance, as most patients do not simply improve by talking. The ability to alter speech with instruction is taken as a positive prognostic indicator, although this assumption has not been tested formally (Duffy, 1995). Feedback is essential to motor learning, especially in early stages, and should be immediate and precise relative to the treatment goals (Schmidt & Lee, 1999; Yorkston et al., 1988). Such feedback should be specific, and can be instrumental or administered by the clinician. Rosenbek and LaPointe (1978) further asserted that the clinician should be as active during DAF-based therapy as during any other form of treatment. Unfortunately, most reports of DAF interventions have not clearly delineated clinician instructions for purposes of replication. What are currently lacking in the literature are studies that demonstrate the effects of simple, consistent, and replicable feedback pertaining specifically to how precisely speakers match the delayed signal. For example, by using headphones and a microphone (as the client does), the clinician is able determine how precisely the client is matching the signal (i.e., she or he can hear the delay that the client hears). Verbal feedback and demonstrations of accurate matching would then be possible via the microphone, which makes the clinician's voice audible to the client. The effects of such instruction on speech measures could be evaluated experimentally by using an A-B-A-B single-subject design (Barlow & Hersen, 1984). For example, speakers might receive DAF alone during the A phases, and DAF + clinician instruction during the B phases. Comparison of performance during the two conditions could then be used to evaluate the relative contributions of the clinician instruction.

These and other aspects of DAF-based rate control protocols need to be evaluated using experimental single-subject designs to determine the effects of task variables on speaker performance. The primary goal of this line of research is not to demonstrate that DAF benefits some speakers under some conditions, but rather which task parameters (e.g., clinician instructions, delay interval, etc.) contribute to its success or failure. Such information could then be used to "fine-tune" the DAF procedure to maximize its efficacy. Factors such as age, cognitive abilities, and pre-morbid speech characteristics may, in part, determine whether or not DAF is an appropriate technique for a particular patient (Dagenais et al., 1998). However, without further studies to evaluate the impact of procedural variables, attributing any lack of success of a DAF intervention to speaker variables may be premature.

Toward that end, Blanchet and Hoffman (in preparation) conducted an initial study to evaluate the impact of clinician instruction on the effectiveness of DAF in improving speech rate, intelligibility, and fluency in speakers with Parkinson's disease. A related purpose of this study was to compare the
effects of different delay intervals on these speech behaviors. It was hypothesized that administering verbal feedback during DAF training would improve performance with all delay intervals used during training. Although an individual speaker might still find one particular interval "optimal," extended training with several intervals may increase proficiency with the remaining intervals. That is, interactions between delay interval and clinician instruction may be demonstrated.

For example, a delay interval of 50 ms may be relatively easy to match, but may not provide enough rate reduction to make a particular speaker sufficiently fluent and/or intelligible. Conversely, an interval of 150 ms may be more difficult to match, but would yield a much slower speech rate. With further practice and clinician feedback, the speaker may develop the ability to match this longer delay more precisely. Therefore, a longer delay interval may ultimately prove to be more beneficial than the interval which was initially deemed "optimal." Alternately, 50 ms DAF may yield five percent disfluency immediately, but produce no further gains with clinician instruction. However, 100 ms DAF may yield ten percent disfluency without instruction (i.e., without being accurately matched by the speaker), but one percent disfluency when supplemented by clinician instruction.

Such findings would suggest that the initial stages of a DAF-based intervention may not be the best time to determine an individual speaker's "optimal delay," as is often done clinically and in the published literature (e.g., Adams, 1994; Hanson & Metter, 1980; 1983).

As stated above, this preliminary study (Blanchet & Hoffman, in preparation) study was conducted in order to obtain information that could later be used to maximize the efficacy and efficiency of DAF. Toward that goal, the purpose of the study was to evaluate the relative contributions of clinician instruction and delay interval on the effectiveness of DAF in treating speech rate, intelligibility, and fluency deficits in adults with dysarthria secondary to Parkinson's disease. Specific research questions were as follows:

1) Does DAF reduce reading rate in speakers with Parkinson’s disease?
2) Does DAF improve intelligibility and/or fluency?
3) Are there differential effects of various delay intervals on speech behaviors?
4) Are there differential effects of clinician instruction on speech behaviors?
5) Does extended use of DAF result in generalization of speech improvements?

The primary research questions addressed not only the issue of whether DAF is effective in reducing speech rate in these patients, but also sought to determine which parameters of the task are most important in maximizing its effectiveness. Information of this nature is potentially useful for speech-language pathologists attempting to use DAF more efficiently with their patients, as well as future investigators in this area. Clinical considerations related to each of these research questions will be discussed in further detail.

**Speech Rate versus Intelligibility**

In general, speech rate is thought to be “excessive” for a particular individual when it is beyond the capabilities of the person’s neuromuscular control system. For example, a Parkinson’s disease patient may actually be speaking more slowly than unimpaired speakers, but may still be speaking at an excessive rate given his or her neuromotor impairment. Appropriate intervention, such as the use of DAF, may result in an even further rate reduction. In such cases, however, the primary goal is not a “normal” speech rate, but “compensated intelligibility.” That is, the primary concern is not how the speaker’s rate compares to normative values, but whether his or her speech can be made more intelligible by reducing its rate (Yorkston et al., 1988).

It has been widely purported that for many dysarthric speakers, intelligibility must take priority over speech rate. For example, Yorkston et al. (1988) recommended that when intelligibility reaches 90%,
increases in speech rate should be attempted. The target rate should continue to increase as long as intelligibility is maintained. Thus, the primary treatment goal should be to use the least intrusive rate control technique that provides adequate rate reduction, while optimizing intelligibility. In the study by Blanchet and Hoffman (in preparation), one of the speakers exhibited over 90% intelligibility with all three DAF settings (i.e., 50 ms, 100 ms, and 150 ms). Therefore, a clinician working with a similar patient might consider continuing treatment with 50 ms DAF, which, being the shortest delay interval, yielded the highest reading rates of the three DAF settings.

The “First Word Dilemma”

Phonatory disturbances, particularly extraneous vocalizations (typically in utterance-initial position) and difficulty initiating phonation, have been reported previously in Parkinson’s disease patients (e.g., Illes, Metter, Hanson, & Iritani, 1988; Kreul, 1972; Metter & Hanson, 1986). These deficits may reflect the need among some patients for improved vocal fold coordination. As discussed in a previous paper (Blanchet, 2006), the smooth transitions between syllables facilitated by DAF reduce the need to reinitiate vocal fold activity (Starkweather, 1987). However, DAF is not always effective in the case of utterance-initial vocalizations or voicing initiation difficulties, as the first syllable or word of an utterance is not “fed back” to the speaker until it has already been initiated. That is, the speaker must be able to initiate a speech segment in order for it to be processed by the DAF unit and “fed back” via headphones. Further studies are needed to evaluate the differential effects of DAF on the frequency of various types of disfluencies. In addition, clinicians using DAF to treat the speech deficits of Parkinson’s disease patients must be aware of such potential limitations, and might consider other interventions for specific disfluencies not eliminated by DAF (e.g., gentle onsets, etc.).

Finding the “Optimal” Delay Interval

Preliminary data suggest that the greatest degree of rate reduction occurs during use of 150 ms DAF (Blanchet & Hoffman, in preparation). This is not surprising, as the longer the duration of the delay interval, the longer the “time lag” between production of a syllable and its perception. In other words, the speaker must prolong each syllable longer while reading with 150 ms DAF than with either 50 ms DAF or 100 ms DAF, resulting in a slower speech rate. Again, previous studies reported speech benefits using delay intervals between 50 ms (e.g., Downie et al., 1981) and 150 ms (e.g., Hanson & Metter, 1983), but have not documented the differential effects of multiple delay intervals across time. As stated above, intervals in excess of 150 ms have reportedly produced adverse effects on the speech of some individuals (Dagenais et al., 1998; Rosenbek et al., 1978).

Previous authors have suggested that in order to minimize such disruptive effects of DAF, users should “speak along with the cadence of the delay time” (e.g., Goldiamond, 1965). Unfortunately, previous studies have not assessed the ability of speakers to match various delay intervals during extended use of DAF. For example, Yorkston et al. (1988) found that increasing the delay interval from 150 ms to 200 ms resulted in no further decrease in speech rate, suggesting that their participant must not have been precisely matching the delayed signal. Likewise, Dagenais et al. (1998) found that altering the duration of the delay interval dramatically produced no systematic changes in speech rate. For one speaker in particular, adjusting the delay interval from 196 ms to 231 ms and then to 0 ms inexplicably resulted in virtually no change in speech rate (Dagenais et al., 1998).

Some Parkinson’s disease patients may respond more favorably to, or may simply prefer, one particular DAF setting. When working with patients achieving substantial speech benefits with different levels of DAF, clinicians are afforded the option of utilizing the setting that the individual speaker prefers or responds most favorably to. Also, early treatment is widely encouraged in Parkinson’s disease to retard the inevitable degeneration of function (Rosenbek & LaPointe, 1978).
Many Parkinson’s disease patients experience a gradually deterioration of communicative abilities as the disease progresses (Adams, 1997). At such time, a longer DAF interval, which would yield a slower speech rate, may be needed to maintain the level of intelligibility and/or fluency previously achieved with a shorter interval (Blanchet, 2006). Extended use of multiple delay intervals during each treatment would afford the patient the opportunity to gain practice with longer intervals, which may need to be used during a later stage of their disease. This may be especially important for relatively young Parkinson’s disease patients, who may eventually experience substantial increases in disease severity.

In addition, the use of delay intervals yielding speech rates slower than needed to achieve significant speech gains is advantageous when increasing the demands of tasks used during treatment. For example, the study by Blanchet and Hoffman (in preparation) employed sentence reading as the sole speech during intervention (i.e., the use of DAF both with and without experimenter instruction). This relatively simple speech-language activity was used in order to maximize the internal validity of the study, and to provide a replicable DAF protocol that could be used easily and effectively by clinicians working with Parkinson’s disease speakers. Previous authors observed that some Parkinson’s disease patients perform better on more structured tasks, such as reading, than on spontaneous speech tasks (Yorkston, Miller, & Strand, 1995). The inclusion of more complex tasks, such as picture description and spontaneous speech, may have accounted for the limited effectiveness of DAF previously reported (e.g., Dagenais et al., 1998; Yorkston et al., 1988).

These findings are not surprising, as spontaneous speech often places increased motor, linguistic, cognitive, and social demands on the speaker (Norris et al., 1998). Reading also facilitates a more rhythmic speech pattern with relatively equal duration between stressed syllables, or “isochrony” (Starkweather, 1987). Clinical evidence suggests that this enhances the use of the DAF signal to predict when the next syllable should be produced (Bloodstein, 1995). Based on these observations, as well as positive preliminary findings (Blanchet & Hoffman, in preparation), clinicians might consider using reading as the sole speech task, at least until stable responding to the DAF has been obtained. Further studies are needed to evaluate the speech effects of DAF using other tasks (e.g., picture description, monologue, conversation, etc.) by conducting systematic replications of the present experiment (Barlow & Hersen, 1984).

The Clinician’s Role in DAF-Based Therapy

As hypothesized, the addition of experimenter instruction to a DAF-based protocol resulted in significantly slower sentence reading rates for all participants (Blanchet & Hoffman, in preparation). In addition, instruction significantly improved intelligibility and speech fluency. Thus, every speech measure positively affected by the use of DAF alone was further enhanced by clinician instruction to a statistically significant extent. Yorkston et al. (1988) suggested that DAF users be trained to not speak rapidly enough to “overdrive” the unit. This enhancement of DAF effects by clinician instruction was expected, and suggests that the initial stage of a DAF-based rate control intervention may not be the best time to determine an individual speaker’s “optimal delay,” as is often observed in the published literature (e.g., Adams, 1994; Hanson & Metter, 1980; 1983).

Thus, pilot data discussed above (Blanchet & Hoffman, in preparation) support the assertion that in order to facilitate optimal use of delayed auditory feedback, clinicians must provide instruction, modeling, and feedback. Such findings may help to delineate clinician instructions for purposes of replication by speech-language pathologists, as well as future investigators. By wearing a headphone/microphone assembly, the experimenter was able to determine how precisely each of the three participants matched the delayed signal throughout the study. Verbal feedback and demonstrations of accurate matching were given as needed by the experimenter (himself a person who stutters and DAF user).
Conclusions

As discussed in previous sections, the overall goal of the study by Blanchet and Hoffman (in preparation) was to obtain data related to the specific speech effects of DAF, and how manipulating specific parameters of the task (i.e., delay interval and clinician instruction) might maximize the effectiveness of DAF as a rate control technique. Thus, priority was given obtaining valid and reliable data related to the acquisition of the DAF-induced speech pattern, rather then to its transfer to habitual speech (i.e., speaking without wearing a DAF unit). The general consensus that the primary use of DAF should be prosthetic (i.e., that effects do not generalize) may be due to the lack of stable acquisition of a DAF-induced speech pattern in previous studies (e.g., Dagenais et al., 1998). Further research is needed to demonstrate the usefulness of DAF as a behavioral rate control intervention, rather than simply a prosthetic device. However, DAF units are often used effectively as prosthetic devices (e.g., Hanson & Metter, 1980; 1983) by individuals who are simply unable to transfer therapy gains to "outside" speaking situations due to the severity of their neuromotor impairments, cognitive limitations, and/or limited access to a speech-language pathologist. The efficacy of DAF used in this capacity also warrants further attention in the literature.

References


