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Research Article

A Clinical Advantage: Experience Informs Recognition and Adaptation to a Novel Talker With Dysarthria

Stephanie A. Borrie,[a] Kaitlin L. Lansford,[b] and Tyson S. Barrett[c]

Purpose: Perceptual training paradigms, which leverage the mechanism of perceptual learning, show that naïve listeners, those with no prior experience with dysarthria, benefit from explicit familiarization with a talker with dysarthria. It is theorized that familiarization affords listeners an opportunity to acquire distributional knowledge of the degraded speech signal. Here, we extend investigations to clinically experienced listeners, speech-language pathologists (SLPs), and advance models of listener recognition and adaptation to dysarthric speech.
Method: Forty-seven SLPs completed a standard three-phase perceptual training protocol (pretest, familiarization, and posttest) with a novel talker with dysarthria. Intelligibility scores were compared with historical data from naïve listeners. Potential relationships between intelligibility scores and characteristics of clinical experience were examined.
Results: Intelligibility scores of SLPs improved by an average of 19% from pretest to posttest. This intelligibility improvement was lower than naïve listeners, although the difference was small. Moreover, clinical characteristics related to level of dysarthria experience (e.g., percent of caseload composed of dysarthria) predicted pretest/initial intelligibility. No predictive relationships between clinical characteristics and intelligibility improvement were revealed.
Conclusions: As a group, SLPs benefitted from perceptual training, suggesting that, despite prior experience, the opportunity to acquire knowledge of talker-specific cue distributions is crucial for optimal adaptation. However, SLPs with greater dysarthria experience were better at initially understanding the talker with dysarthria. This suggests that, through regular interaction with individuals with dysarthria, clinicians acquire knowledge of the cue distributions of dysarthric speech more generally and can generalize this group-specific knowledge to aid in understanding other talkers with dysarthria. Consistent with theoretical models of perceptual learning, both talker- and group-specific knowledge informed recognition and adaptation to dysarthric speech.

Perceptual learning describes the idea that listeners can learn to better understand degraded, or otherwise noncanonical, speech. A body of literature has experimentally examined perceptual learning of dysarthric speech, whereby naïve listeners, individuals with no previous experience with neurological speech disorders, are explicitly familiarized with the degraded speech signal. Intelligibility performance before and after the familiarization experience, and/or a control condition in which listeners are familiarized with neurotypical speech, show statistically significant intelligibility improvements for listeners familiarized with dysarthric speech (e.g., Borrie et al., 2017a, 2012; although see Lansford et al., 2019, 2020, for the case of hyperkinetic dysarthria, where familiarization with unpredictable speech does not improve intelligibility). Successful speech perception requires listeners to map the continuous, incoming signal onto discrete meanings. When listeners encounter a talker with a novel way of speaking (e.g., dysarthria), the speech recognition system must rapidly and flexibly adapt, mapping the noncanonical acoustic cues onto linguistic categories stored in the memory. As there is much intratalker variability (e.g., Allen et al., 2003; Newman et al., 2001), these mappings are, in essence, probabilistic (Kleinschmidt & Jaeger, 2015). Thus, it is assumed that the familiarization experience affords the listener an opportunity to engage in statistical learning, acquiring knowledge of the talker's category-specific cue distributions (e.g., Clayards et al., 2008;

[a]Department of Communicative Disorders and Deaf Education, Utah State University, Logan
[b]School of Communication Science and Disorders, Florida State University, Tallahassee
[c]Department of Psychology, Utah State University, Logan
Correspondence to Stephanie A. Borrie: stephanie.borrie@usu.edu, www.humaninteractionlab.com

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Feldman et al., 2009). In subsequent encounters with the same talker, the listener can draw upon their previous experience (i.e., knowledge of the talker's cue-to-category mappings) to more successfully decipher the incoming signal (e.g., Eisner & McQueen, 2005; Kraljic & Samuel, 2007). While a detailed review is beyond the scope of this study, collectively, the literature on perceptual learning of dysarthric speech (e.g., Borrie & Schäfer, 2015; Kim & Nanney, 2014; Lansford et al., 2018; Liss et al., 2002) has laid the groundwork for explicit familiarization (also termed *perceptual training*) as an alternative intelligibility intervention to manage the dysarthrias, one that shifts the weight of behavioral change from the speaker to the (naïve) listener.

Clinically, the next question is: What about listeners who regularly interact with individuals with neurological speech disorders? Would such listeners, experienced listeners, benefit from perceptual training with a novel talker with dysarthria? Or does regular interaction with talkers with dysarthria result in completely adapted listeners, those who have learned all there is to know about the degraded speech signal? The *ideal adaptor* framework, a computational theory of speech perception (Kleinschmidt & Jaeger, 2015), allows us to make predictions about the role of prior experience in recognition and adaptation to a novel talker with dysarthria. The basic premise of the ideal adaptor is that the speech perception system is sensitive to structured variability and will exploit previous experience as able. In addition to the intratalker variability noted above, cue distributions differ from talker to talker (the *lack of invariance* problem; see Liberman et al., 1967). Thus, talker-specific experiences will inherently be most formative for understanding that talker. However, the ideal adaptor allows listeners to take advantage of distributional structure that unifies groups of talkers, those with a similar way of speaking (e.g., dialect, accent). That is, experience with talkers from the same group enables the listener to generate group-specific cue distributions that aid in understanding other talkers with group membership (e.g., Spanish-accented talkers; Sidaras et al., 2009). Accordingly, listeners who have engaged in prior interactions with talkers with dysarthria may have learned cue distributions of dysarthric speech more generally, group-specific knowledge, allowing them to be more successful in future encounters with novel talkers with dysarthria.

Empirical support for ideal adaptor predictions regarding a role for both talker- and group-specific knowledge has been found in experimental studies of generalized learning across talkers with dysarthria (Borrie et al., 2017a; Hirsch et al., 2021). To examine learning generalization, Borrie et al. (2017a) randomly assigned 160 naïve listeners to one of eight familiarization conditions, each a different talker with dysarthria or, alternately, a control talker with neurotypical speech. All listeners were tested on the same talker with ataxic dysarthria following the familiarization experience. The study found that listeners familiarized with a talker with dysarthria, regardless of presenting speech characteristics, were better at understanding the test talker. However, the magnitude of benefit tracked with the level of perceptual similarity between the test talker and the talker experienced during familiarization. Hirsh et al. (in press), also using naïve listeners, confirmed the role of perceptual similarity in generalized adaptation to dysarthric speech, further evidencing generalization across talker sex. Collectively, the results of these studies suggest that listeners are sensitive to distributional regularities in shared structure, acquiring knowledge about the cues that unify the dysarthrias as a group of motor speech disorders (i.e., dysarthria-general features; characteristics such as slow speaking rate, imprecise consonants, and reduced vowel space; see Weismer & Kim, 2010). However, that intelligibility of the test talker was superior for naïve listeners familiarized with talkers with same/similar-sounding dysarthrias evidenced sensitivity to distributional regularities in specific structure (i.e., dysarthria-specific features) and the utility of talker-specific knowledge. How prior, real-world experience with talkers with dysarthria impacts distributional knowledge and perceptual training with a novel talker with dysarthria is currently unknown.

Speech-language pathologists (SLPs) have prior experience, albeit to varying degrees, working with individuals with dysarthria. Therefore, it is plausible to posit that SLPs have acquired some preexisting knowledge about the speech structure of dysarthria more generally and can draw upon this group-specific knowledge when a new talker with dysarthria is encountered. Support for this idea, that SLPs have already engaged in some level of adaptation to dysarthric speech, has been revealed in a handful of clinically based studies. In descriptive reports, Dagenais et al. (1998, 1999) observed higher intelligibility scores for SLPs ($n = 10$), relative to naïve listeners, transcribing the speech of talkers with dysarthria. This finding did not extend to SLP students. Smith et al. (2019) reported no difference in intelligibility scores of SLP students (those trained in speech-related topics but no clinical experience) compared to individuals from the general public. Similarly, DePaul and Kent (2000) found no difference in the intelligibility scores of SLP students relative to business students. Thus, it could be assumed that clinical experience, presumably interactions with individuals with dysarthria, is required for learning to transpire. Here, we ground the study of the role of clinical experience in recognizing and adapting to talkers with dysarthria within a theoretical framework and experimental paradigm. Metrics that capture the nature of the clinical experience are included to corroborate assumptions about the role of prior experience with dysarthric speech.

Current Study

The purpose of the current study was to investigate the influence of clinical experience on perceptual learning of dysarthric speech. An established three-phase perceptual training protocol (pretest, familiarization, and posttest) was used to address two research questions. The first question targeted the influence of clinical experience broadly, asking: (a) Do SLPs, representing a group of experienced listeners, benefit from familiarization with dysarthric speech, as previously evidenced in naïve listeners? The second research

question specifically targeted the nature of the clinical experience and intelligibility comparisons, asking: (b) Do characteristics of the clinical experience predict initial intelligibility and the magnitude of intelligibility improvement following familiarization with dysarthric speech? Based on theoretical models that emphasize the contribution of prior experience in deciphering nonconical speech (Kleinschmidt & Jaeger, 2015), and empirical studies of learning generalization across talkers with dysarthria (Borrie et al., 2017a; Hirsch et al., 2021), it was hypothesized that clinical experience would influence perceptual learning of dysarthric speech. This is to say that SLPs would benefit from explicit familiarization with a novel talker with dysarthria but that this perceptual benefit would be less than that achieved by naïve listeners, suggesting some *in-the-wild* statistical learning of group-specific structure may have already transpired. Furthermore, with the targeted analyses of the second research question, it was hypothesized that SLPs with greater dysarthria experience, relative to SLPs with less dysarthria experience, would be better at initially understanding a novel talker with dysarthria and may thus benefit to a smaller extent from explicit familiarization.

Method

Participants

Forty-seven certified SLPs, aged 26–62 years old (M_{age} = 35.04, SD = 8.82), participated in the current experiment, representing a group of clinically experienced listeners. Beyond American Speech-Language-Hearing Association certification, inclusion criteria required that all participants be native speakers of American English and have no self-identified speech, language, or hearing impairment. While not a target of recruitment, all participants identified as female and represented regions from across the United States. Data regarding characteristics of the SLPs' clinical experience were also collected, comprehensively detailed in the procedures below and summarized in Table 1. Participants were recruited using convenience sampling through advertisements on social media, including SLP-focused Facebook groups and Instagram. As an incentive, participants were entered into a lottery draw for one of four $50 Amazon gift cards.

Table 1. Characteristics of the speech-language pathologists (SLPs).

Characteristic	*N* = 47
Years SLP, median (range)	8 (1, 36)
Current setting	
Medical	17 (36%)
School	12 (26%)
Early intervention (EI)	3 (6%)
University	15 (32%)
Percent caseload	
0%	10 (21%)
1%–20%	14 (30%)
21%–40%	8 (17%)
41%–60%	7 (15%)
61%–80%	4 (8.3%)
81%–100%	4 (8.3%)
Perceived competence	
1	2 (4.3%)
2	3 (6.4%)
3	4 (8.5%)
4	6 (13%)
5	7 (15%)
6	17 (36%)
7	8 (17%)
Region	
Midwest	7 (15%)
Northeast	10 (21%)
Pacific	7 (15%)
Rocky Mountain	10 (21%)
Southeast	7 (15%)
Southwest	6 (13%)

Note. "Years SLP" refers to the number of years spent working in this occupation. "Work setting" refers to current work setting. "Percent of caseload" refers to the clinicians' estimate of the percent of their caseload that is composed of individuals with dysarthria. "Perceived competence" refers to the clinicians' perception of their competency in evaluating or treating individuals with dysarthria. SLP = speech-language pathologist.

Speech Stimuli

The speech stimuli used in the current study have been used previously in studies of perceptual learning of dysarthric speech with naïve listeners, those with no prior experience with talkers with neurologically degraded speech (Borrie et al., 2017a). Stimuli consisted of audio-recorded productions of a set of 80 semantically anomalous phrases and a reading passage produced by a male talker of American English with a speech diagnosis of ataxic dysarthria secondary to cerebellar disease (see Liss et al., 2009, for a description of the stimuli recording procedures). The talker exhibited the cardinal perceptual speech characteristics of ataxic dysarthria, including reduced articulation rate, irregular articulatory breakdowns, excess and equal stress, harshness, monotone, and monoloudness. Acoustic validation of the talker's perceptual characteristics has been reported in earlier studies (Lansford & Liss, 2014a, 2014b; Liss et al., 2009).

The speech stimuli were used in the development of a three-phase perceptual training protocol (pretest, familiarization, and posttest). The set of 80 syntactically plausible but semantically anomalous phrases, designed to reduce the influence of contextual knowledge on intelligibility performance, were used as stimuli for the pretest (20 phrases[1]) and posttest (60 phrases) transcription tasks. These six-syllable phrases alternated in metrical stress and ranged from three to five words in length (e.g., *had eaten junk and train* and *rowing father matters*). The audio recordings of the reading passage, an adapted version of the Grandfather Passage, were paired with an orthographic transcription and used as stimuli for the familiarization phase of the protocol. The passage consisted of 35 phrases, ranging in length from three to 12 words.

[1]The pretest was used to yield baseline intelligibility data (initial intelligibility). It is, however, important to keep the pretest as brief as possible so that improvements following familiarization (intelligibility improvement) can be attributed to perceptual training rather than experience with the talker during pretest.

Procedure

Interested participants were given a study weblink, directing them to the experiment hosted on a secure university-based web server.[2] Before beginning the study, participants were told that, to participate in the study, they would need to wear headphones and have 30–40 min of uninterrupted time available. They were also required to read through the institutional review board–approved consent, including the study inclusion criteria. If the inclusion criteria were met and consent agreement was indicated, participants were permitted to continue with the study.

The first part of the study required participants to complete a series of questions related to their clinical experience as a certified SLP, with a focus on working with individuals with dysarthria. Appendix details the questions: In brief, four characteristics of clinical experience were targeted for the current study: (a) years of experience (years SLP), (b) current work setting (current setting), (c) estimate of the percent of caseload composed of individuals with dysarthria (percent caseload), and (d) perception of competency in management of individuals with dysarthria (perceived competence). For percent caseload, participants were given the following percent range options to identify approximately what percent of their caseload was composed of individuals with dysarthria: 0%, 1%–20%, 21%–40%, 41%–60%, 61%–80%, and 81%–100%. For perceived competence, participants were asked to indicate, using a 7-point Likert-type rating scale with standard response anchors, the extent to which they agreed with the following statement: *I feel competent assessing and treating individuals with dysarthria*. These details are also reported in Table 1.

The second part of the study required participants to complete a talker-specific, three-phase perceptual training protocol, identical to that used in earlier studies (Borrie et al., 2017a; Lansford et al., 2018). For the pretest, participants were informed that they would be presented with short phrases produced by a talker with a speech disorder and that their task was to listen to each phrase and type out what they thought was being said. They were also told that the phrases all contained real English words; however, the phrases would not necessarily make sense. Participants could only listen to each phrase once but could take as much time as necessary to type their response. Immediately following the pretest (20 phrases), participants underwent the familiarization phase where they were told that they would hear a short passage reading (Grandfather Passage) produced by a talker with a speech disorder and would see written subtitles of what was being said on the screen. They were told that their task was to listen to the talker's productions while simultaneously following the orthographic transcription. Finally, participants completed the posttest (60 phrases). The instructions were identical to the pretest, in which participants were asked to listen to short phrases and type what they thought was being said. Presentation of phrases in both the pretest and posttest was randomized across participants.

Transcript Analysis

Listener transcripts from the pretest and posttest phases of the perceptual training protocol were scored for words correct using Autoscore, an open-source, computer-based tool for automated scoring of transcriptions (http://autoscore.usu.edu/; Borrie et al., 2019).[3] Autoscore has scoring rules that can be selected, depending on the needs of the project. Here, we applied the same rules as have been used in our previous studies. Words were scored as correct if they matched the intended target exactly or differed only by tense or plurality. Homophones and obvious spelling errors were scored as correct using a preprogrammed "default" list of common misspellings. A percent words correct (PWC) score was tabulated for the pretest and posttest phases, resulting in a pretest PWC score and a posttest PWC score for each listener. The pretest PWC score reflects intelligibility before familiarization and, thus, with no further transformation, forms the initial intelligibility score. The intelligibility improvement score was calculated by subtracting the pretest PWC score from the posttest PWC score.

Data Analysis

Historical Data Set

Intelligibility data collected from the SLPs in the current study were compared with historical data from naïve listeners, those with no prior experience with talkers with dysarthria, and previously reported in Borrie et al. (2017a). Full details of this data set can be found in the previous article; however, the historical data set included here for reference data consisted of a group of 20 naïve listeners who completed the same perceptual training protocol, with the same speech stimuli (same-speaker condition), and a group of 20 listeners who completed the same pretest and posttest but were familiarized with speech produced by a neurotypical talker (control condition). Comparable to the SLP participants in the current study, inclusion criteria required that all participants be native speakers of American English with no self-identified speech, language, or hearing impairment. The mean age of participants was 31.04 years. Furthermore, the study was also conducted remotely, via the crowdsourcing website, Amazon Mechanical Turk. Thus, historical data and data from the current study differed only in terms of whether listeners were experienced or naïve and whether control familiarization was received.

Statistical Analysis

Research Question 1. To determine if SLPs (i.e., experienced listeners) benefit from familiarization with dysarthric speech, changes in intelligibility from pretest to

[2]We have previously reported on the validity (Lansford et al., 2016) and utility (Borrie et al., 2017a, 2018) of online perceptual training experiments with dysarthria speech.

[3]The accuracy of Autoscore relative to human scorers has been previously validated (Borrie et al., 2019).

posttest PWC (intelligibility improvement) were initially assessed using a simple paired-samples t test. We then assessed differences in intelligibility improvement across the three listener conditions (experienced, naïve, and control) using multiple linear regression with intelligibility improvement predicted by condition, controlling for pretest PWC (initial intelligibility) scores. This approach provides comparisons of intelligibility improvement between the three conditions while accounting for differences in initial intelligibility (i.e., comparing improvement after making all individuals statistically equal at pretest). We also assessed differences between the conditions for initial intelligibility, again using linear regression. We used the experienced listener condition as the reference category. It is worth noting that the inclusion of the previously published data permits a well-powered comparison with the experienced listener condition.

Research Question 2. To determine whether clinical characteristics were predictive of initial intelligibility and the magnitude of intelligibility improvement following familiarization with dysarthric speech, only data from the SLPs were used ($n = 47$). The four clinical characteristics of interest included years as SLP, current setting, percent caseload, and perceived competence. For current setting, only three participants reported early intervention (EI). Given the EI caseload, like schools, consists of pediatric populations, we combined EI and schools as a single grouping variable. For percent caseload, only four participants reported 61%–80% and 81%–100%. To allow adequate group information to estimate differences, we combined caseloads greater than 40% as a single grouping variable. As an initial validity check, chi-square and correlations were used to explicate how characteristics of the clinical experience covary. In theory, metrics of current setting, percent caseload, and perceived competence should be related in terms of level of dysarthria experience, whereas years SLP should not be related.

Using multiple linear regression modeling, we examined potential predictive relationships between the four clinical experience characteristics and initial intelligibility and intelligibility improvement, with the latter controlling for initial intelligibility. Lastly, linear contrasts were used to investigate specific differences between the levels of any categorical characteristics that demonstrated omnibus significance. Because of the multiple tests used herein, we adjusted our alpha level to be .004 (using the Bonferroni adjustment). Assumptions of the various statistical approaches were assessed. All analyses were conducted in R Version 4.0.2 (R Core Team, 2019) with the gtsummary and tidyverse packages (Sjoberg et al., 2020; Wickham et al., 2019). All code, output, and data are provided at http://osf.io/prf95.

Results

Research Question 1

Intelligibility data, reported as PWC, from pretest to posttest for each participant across listener conditions (experienced, naïve, control) are presented in Figure 1. The initial paired t test revealed that intelligibility scores of the experienced listeners, the SLPs, significantly improved from pretest ($M = 51.9$) to posttest ($M = 70.5$), $t(46) = 23.1$, $p < .001$. The regression results (see Table 2) revealed that the intelligibility improvement achieved by experienced listeners was significantly lower than naïve listeners; however, the difference is relatively small (b = 4.2 percentage points, $p < .001$).[4] The intelligibility improvement achieved by the experienced listeners was significantly greater than the control condition, wherein listeners were familiarized with neurotypical speech (b = −16 percentage points, $p < .001$). These intelligibility improvement scores controlled for initial intelligibility, even though, on average, there were no significant differences for initial intelligibility between the listener conditions, $F(2, 84) = 2.06$, $p = .134$.

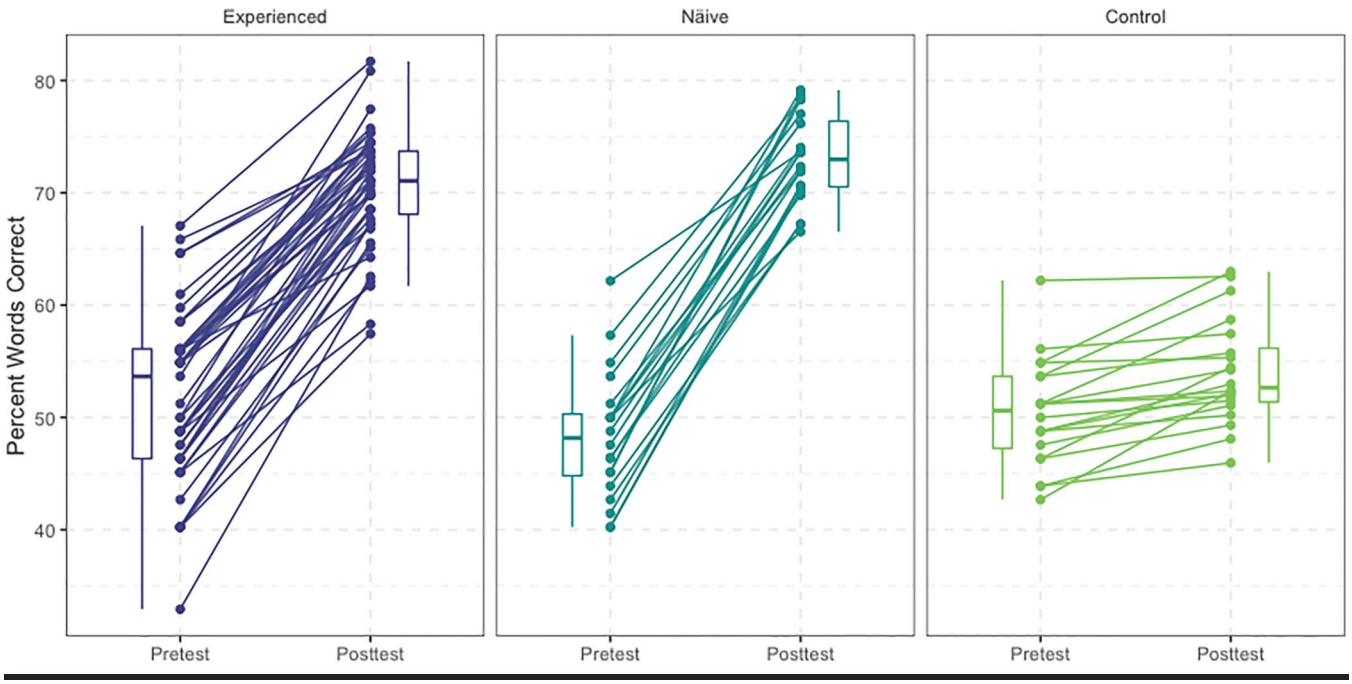
Research Question 2

As expected, three of the four characteristics of clinical experience, percent caseload, current setting, and perceived competence were significantly related to each other (all ps < .004). Figure 2 describes the relationships between these clinical characteristics, showing the proportions of individuals in each setting (quantified along the y-axis) that are in each percent caseload category, and how these proportions are further related to perceived competence. To illustrate, the figure shows that a large proportion of SLPs who work in medical and university settings have a higher percent of caseload composed of dysarthria and a higher level of perceived competency in assessing and treating dysarthria. Accordingly, these three clinical characteristics can be considered relative to the construct of level of dysarthria experience. Furthermore, as expected, there were no relationships between years as an SLP and any of the other clinical characteristics (all ps > .270).

The results of the predictive models are presented in Table 3. As reported, three of the four characteristics of clinical experience, current setting, percent caseload, and perceived competence, predicted initial intelligibility scores. Each relationship has moderate-to-large R^2 values. Figure 3 highlights these relationships, presenting intelligibility scores, indexed by PWC for pretest and posttest, for the three clinical characteristics. Linear contrasts specified these relationships for initial intelligibility, comparing individual levels of both categorical clinical characteristics (percent caseload and current setting). First, the 41%–100% caseload category was significantly different than 0% ($p < .001$), 1%–20% ($p = .003$), and 21%–40% ($p = .008$). The 0%, 1%–20%, and 21%–40% categories were not significantly different (ps > .220). Second, the school + EI setting was significantly different from both university and medical settings (ps < .001) while university and medical were not significantly different ($p = .600$). Finally, because perceived competence is not categorical, we do not compare the levels individually. Still, it is important to note that, in general, the individuals tend to have higher initial intelligibility as one moves higher on the perceived

[4] b refers to the unstandardized regression estimate, quantifying effect size in terms of percentage points.

Figure 1. Intelligibility scores, indexed by percent words correct, for pretest and posttest, with box plots showing distributional spread. The first panel reports data from the experienced listeners in the current study. The second and third panels report historical data from naïve listeners and control listeners, respectively (Borrie et al., 2017a).



competence scale, as is reported by the positive estimate in Table 3. As also reported in Table 3 and illustrated in Figure 3, none of the clinical experience characteristics predicted intelligibility improvement scores when controlling for initial intelligibility scores.

Discussion

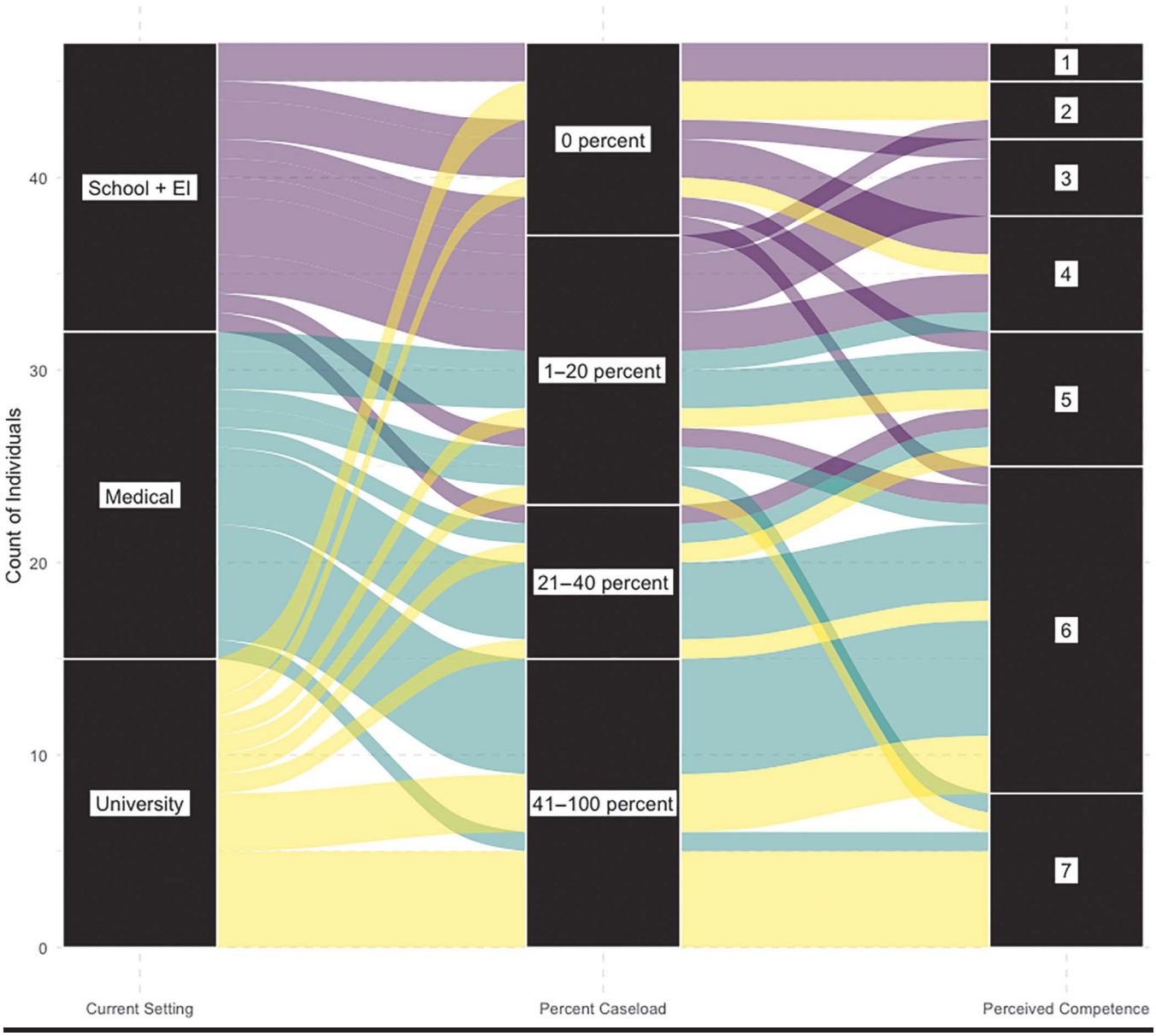
A body of existing literature has established that naïve listeners, those with no prior experience with talkers with dysarthria, benefit from explicit familiarization with a talker with dysarthria. Here, we extend these findings to experienced listeners, SLPs, and advance models of listener recognition and adaptation to dysarthric speech. Our first research question targeted the influence of clinical experience broadly. Consistent with our theoretically motivated hypothesis, we found that SLPs, as a group of clinically experienced listeners, benefited from explicit familiarization with a novel talker with dysarthria. Specifically, the SLP group achieved an average intelligibility gain of 19%, which was significantly greater than listeners familiarized with neurotypical speech. That SLPs benefited so considerably from perceptual training suggests that, despite previous experience, the opportunity to acquire knowledge of talker-specific cue distributions is crucial for optimal adaptation to a particular talker with dysarthria, consistent with ideal adaptor theories of learning (Kleinschmidt & Jaeger, 2015). The results also revealed that the perceptual benefit observed for SLPs was less than that observed in historical data from naïve listeners who achieved, on average, a 24% intelligibility gain from the same explicit

Table 2. Regression model estimates comparing the conditions, with experienced listeners as the reference group.

Variable	Initial intelligibility				Intelligibility improvement			
Characteristic	Estimate	95% CI	*p* value	Standardized estimate	Estimate	95% CI	*p* value	Standardized estimate
Condition								
Experienced	[Ref]	[Ref]	[Ref]	[Ref]	[Ref]	[Ref]	[Ref]	[Ref]
Control	−1.5	[−5.0, 2.0]	.400	−0.23	−16	[−18, −14]	< .001	−1.8
Naïve	−3.5	[−7.0, −0.04]	.048	−0.53	4.2	[2.2, 6.2]	< .001	0.48
R^2			0.05			0.83; 0.71 without initial intelligibility		

Note. The model for intelligibility improvement controlled for initial intelligibility. CI = confidence interval.

Figure 2. Experienced listeners plotted according to clinical characteristics: current setting, percent caseload, and perceived competence. This shows the proportions of individuals in each setting that are in each percent caseload category and how these proportions are further related to perceived competence, illustrating significant relationships between these three characteristics. University, medical, and school + early intervention (EI) are represented by yellow, green, and purple, respectively.



familiarization experience (Borrie et al., 2017a). While small, this would seem to suggest that, in general, the real-world interactions that SLPs encounter through their occupational practices may facilitate some unstructured perceptual learning of dysarthric speech. Though naïve listeners and SLPs, when considered a broad group, were statistically equal at pretest, the more targeted analyses of Research Question 2 allow for a comprehensive examination of this speculation.

Our second research question specifically targeted the nature of clinical experience, examining four characteristics including years as an SLP, current work setting, percent caseload composed of dysarthria, and perceived competence in managing dysarthria. Again, in line with the ideal adaptor framework predictions, we found that the three characteristics related to *greater dysarthria experience*—current work setting, percent caseload, and perceived competence—tracked with greater initial intelligibility scores. That is, (a) SLPs who worked in either a medical or university setting were significantly better than SLPs who worked in the school or EI setting (approximately 8.5 percentage points lower) at recognizing the novel talker with dysarthria upon

Table 3. Regression models assessing initial intelligibility and intelligibility improvement.

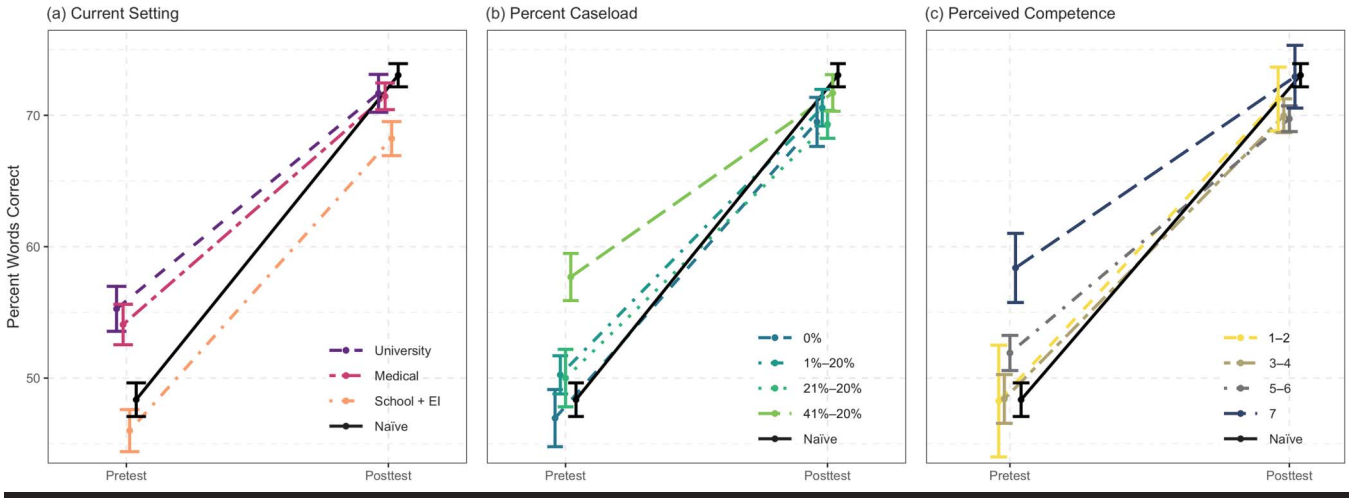
Initial intelligibility				
Clinical characteristic	***F* statistic**	***p* value**	**R^2**	
Years SLP	0.61	.439	.01	
Current setting	9.46	< .001	.30	
Percent caseload	6.66	< .001	.32	
Perceived competence	9.88	.003	.18	
Intelligibility improvement				
Clinical characteristic	***F* statistic**	***p* value**	**R^2**	**R^2 without initial intelligibility**
Years SLP	0.06	.813	.45	.01
Current setting	0.22	.806	.46	.10
Percent caseload	1.99	.130	.52	.04
Perceived competence	7.13	.011	.53	.01

Note. All models with intelligibility improvement as the dependent variable control for initial intelligibility (pretest percent words correct). SLP = speech-language pathologist.

initial encounter, (b) SLPs with caseloads consisting of greater than 40% dysarthria were significantly better than SLPs with caseloads below 40% dysarthria (approximately 6 percentage points lower) at recognizing the novel talker with dysarthria upon initial encounter, and (c) SLPs with higher levels of perceived competency in assessing and treating dysarthria were significantly better than SLPs' lower levels of perceived competency at recognizing the novel talker with dysarthria upon initial encounter. Given substantial overlap between clinical metrics, it is not surprising that all three characteristics were significant predictors of initial intelligibility scores. These findings would suggest that, through working with individuals with dysarthria, clinicians generate group-specific cue distributions about dysarthria-general features and can generalize this knowledge to aid in understanding a novel talker with dysarthria. The one metric that does not directly relate to greater dysarthria experience—years as SLP—did not predict initial intelligibility scores. Collectively, the study of these four clinical experience characteristics and their relationship with initial intelligibility scores confirm our earlier speculation that it is the degree of clinical experience with dysarthria, and not merely the SLP occupation, that is responsible for the perceptual advantage in recognizing dysarthric speech.

As previously mentioned, Dagenais et al. (1998, 1999) reported higher intelligibility scores for SLPs, relative to naïve listeners, transcribing dysarthric speech. At first glance, the current findings appear in conflict; the analyses for our first research question revealed that listeners in all conditions were statistically equal at pretest. Nontrivial, however,

Figure 3. Average intelligibility scores, indexed by percent words correct, for both pretest and posttest, for experienced listeners by (a) current setting, (b) percent caseload, and (c) perceived competence. All three panels show that initial intelligibility differs as a function of the clinical characteristic, whereas intelligibility improvement does not. For visual reference, historical data from naïve listeners are included in all three panels (Borrie et al., 2017a).



is that the SLPs recruited for the earlier studies were required to have a minimum 2 years of experience working with patients who have dysarthria and, as such, represent SLPs with considerable dysarthria experience. Thus, the current finding, that SLPs with greater dysarthria experience outperformed those with less dysarthria experience at pretest, appears largely consistent with earlier descriptive reports. One important finding that emerges from the current, larger scale study of clinically experienced listeners is that SLPs do not represent a homogenous group of listeners in terms of their ability to recognize dysarthric speech. It is only by classifying SLPs according to current setting/percent caseload/perceived competence (reflecting dysarthria experience) that the influence and perceptual advantage of prior experience can be realized.

Our second research question also addressed whether characteristics of the clinical experience predicted intelligibility improvement scores. We had expected that SLPs with greater dysarthria experience would benefit less from explicit familiarization, surmising that dysarthria-general cue-to-category mappings had already been established through prior real-world interactions (evidenced in the results from the first part of this research question), and thus, the listener need only update beliefs about the talker-specific behavior. However, no characteristics of the clinical experience predicted intelligibility improvement scores. We entertain two possible explanations for the absence of the anticipated relationship. Firstly, visual inspection of the data classified by percent caseload (see Figure 3, Panel 1) suggests that SLPs with caseloads consisting of greater than 40% dysarthria may have benefited to a lesser degree from explicit familiarization; however, increased participants' numbers may have been necessary for this relationship to be realized. Alternatively, it is entirely possible that the relationship between percent caseload and intelligibility improvement would not become apparent with more participants. That is, while greater dysarthria experience afforded a robust gain for initially recognizing the degraded speech signal, the extent to which a listener benefits from explicit familiarization may be driven by factors other than, or in tandem with, prior experience. In a previous study, expertise in rhythm perception was shown to have no influence on naïve listeners' ability to initially decipher a talker with dysarthria but was a significant predictor of intelligibility improvement following explicit familiarization (Borrie et al., 2017b, 2018). The assumption there that individuals with superior rhythm perception abilities more accurately detect (and thus map) probability distributions of the acoustic cues associated with each linguistic category. Therefore, the second explanation for the lack of relationship between dysarthria experience and intelligibility improvement following perceptual training is that other listener parameters, not assessed in this study, may be at play. The influence and potential interaction between theoretically motivated listener parameters warrant future investigation.

The results of this study have important clinical implications for perceptual training, particularly as it pertains to issues of candidacy in terms of listeners (see Lansford et al., 2020, for results that have implications for candidacy in terms of speakers). The intelligibility impairments that characterize dysarthria have been described as "the most clinically and socially important aspects of dysarthria" (Ansel & Kent, 1992) and track with social isolation and emotional distress (Dickson et al., 2008; Hartelius & Svensson, 1994). Thus, a central goal of dysarthria management is to improve speech intelligibility. While we have previously demonstrated perceptual training, or explicit familiarization, as a promising platform for improving intelligibility of dysarthric speech, that was only for naïve listeners, those with no significant prior experience with talkers with dysarthria. Here, we show that SLPs, even those highly experienced in working with dysarthria (i.e., greater than 40% dysarthria on their caseload), benefit from talker-specific perceptual training. Indeed, the SLP group average of 19% intelligibility improvement following perceptual training is not insignificant given that intelligibility improvements of 5%–12% are considered a guideline for clinically significant change in dysarthria management (Stipancic et al., 2016, 2018; Van Nuffelen et al., 2010).

It is intuitive to consider that the findings of this study would extend to other experienced listeners, indicating that other professionals who work with individuals with dysarthria (e.g., neurologists, social workers, physical therapists, dietitians) would also benefit from talker-specific perceptual training for improved understanding of a talker with dysarthria. What remains unknown is if experienced listeners, including SLPs, would benefit from generalized training paradigms (i.e., training on talkers with dysarthria for improved understanding of other talkers with dysarthria; Borrie et al., 2017a). The current results, that SLPs with greater dysarthria experience are better able to understand a novel talker on initial encounter, indicate that these listeners have already acquired useful group-specific knowledge regarding dysarthria-general distributions. As such, listeners whose occupation requires frequent interaction with individuals with dysarthria, highly experienced listeners, may be suitable candidates for perceptual training when talker-specific adaptation is desired. However, highly experienced listeners may have learned all there is to know about dysarthria-general distributions. Whether talker-general training paradigms are advantageous for highly experienced listeners should be investigated.

While the data collection from 47 SLPs for the current study was appropriate (and practical), the findings regarding the role of clinical experience are limited, to some degree, by relatively small participant numbers. As mentioned above, visual inspection of the data classified by percent caseload suggests that SLPs with high dysarthria caseloads may have benefited to a lesser degree from explicit familiarization; however, the predictive model for this relationship was not significant. Thus, future research into the nature of the perceptual benefit associated with clinical experience should aim for greater participant numbers. Given the study length, providing monetary remuneration for all participants, instead of a lottery draw, may help achieve this goal.

The use of self-report measures of clinical experience, specifically the more subjective measures that asked participants

to estimate their percent caseload and their perceived competence in working with dysarthria, should also be raised as a potential limitation of this work. While the data suggest these three correlated characteristics tapped into the theoretical construct of level of dysarthria experience, it would be prudent to acknowledge the potential for misunderstandings and self-reporting bias in such measures. Relatedly, while online speech perception experiments frequently utilize self-report to exclude participants with hearing loss, we recognize this is not the optimal method to rule out possible hearing impairment.

Finally, to control for learning that may transpire from just engaging in the familiarization protocol, we included historical data from a control group of naïve listeners who underwent explicit familiarization with stimuli produced by a neurotypical talker. Perhaps the ideal control group, or at least an additional control, would have consisted of SLPs. This would have allowed for direct comparisons between SLPs familiarized with dysarthric speech and those familiarized with neurotypical speech. However, recruiting SLPs for a study that takes up to 40 min of uninterrupted attention was not easy. Furthermore, given that SLPs do not represent a homogenous group of experienced listeners, participants would need to be matched by clinical characteristics, making the collection of this level of control a considerable challenge.

Conclusions

The current study shows that SLPs, representing a group of clinically experienced listeners, benefit from perceptual training with dysarthric speech. That is, similar to naïve listeners, SLPs were better able to decipher a novel talker with dysarthria following explicit familiarization with that same talker. However, SLPs do not represent a homogenous group of experienced listeners in terms of recognizing and adapting to dysarthric speech. Key is that the SLPs with greater dysarthria experience were better at understanding a novel talker with dysarthria upon initial encounter. This suggests that some level of perceptual adaptation, namely, acquiring knowledge of the cue distributions of dysarthric speech more generally, group-specific knowledge, had already transpired for those clinicians who frequently interact with individuals with dysarthria. Collectively, the results of this study afford empirical support for theoretical models of perceptual learning, which posit a role for both talker- and group-specific knowledge.

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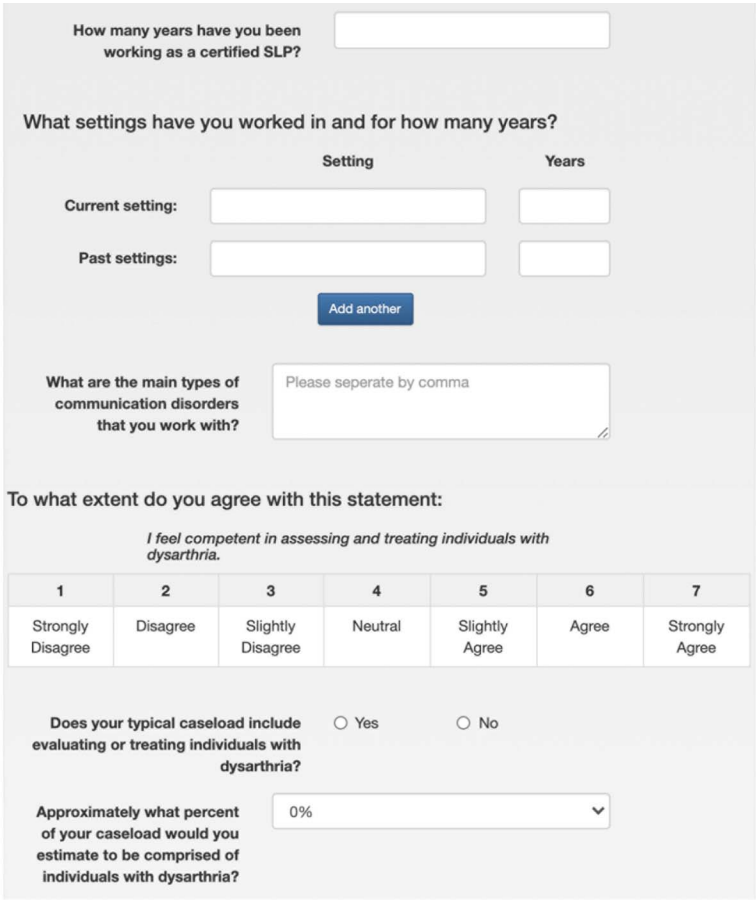
Appendix

Clinical Experience Questions


How many years have you been working as a certified SLP?

What settings have you worked in and for how many years?

	Setting	Years
Current setting:		
Past settings:		

Add another

What are the main types of communication disorders that you work with?

Please seperate by comma

To what extent do you agree with this statement:

I feel competent in assessing and treating individuals with dysarthria.

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree

Does your typical caseload include evaluating or treating individuals with dysarthria? ○ Yes ○ No

Approximately what percent of your caseload would you estimate to be comprised of individuals with dysarthria? 0%