Gradient phonetic and categorical phonemic perception in adult language learning

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Models of second language acquisition predict learning outcome of adult foreign or second language learners. Out of those, two models namely, Perceptual Assimilation Model (PAM: Best, 1995, 1994) and Feature Model (FM: 1998, 2000) were considered in this study. The PAM classifies sounds of L2 into categories and predicts a directionality of difficulty for learners. The FM on the other hand, predicts that feature geometry of L1 is vital in perception of L2 sounds. The current study aims to test these predictions and determine which of the models is more suitable for Pakistani learners of English. A perception experiment was conducted with 8 adult Indian learners of English who were living in and around London at the time of experiment. The experiment aimed to test the participants' perception of English consonants [f ð θ ʒ w v]. It contained an identification and a discrimination test. The results of identification test were used to confirm if the hypotheses of the current study were rightly developed in the light of predictions of the PAM or not. For confirmation of the hypotheses, the discrimination test was arranged. The results of the discrimination test partially confirm predictions of the PAM but reject those of the FM. The current study also concludes that by using a statistical perceptual overlapping method directionality of difficulty between such pairs of sounds which lie in the same category may be developed.

Key words: *consonant, learning, L2, PAM, perception, Feature Model*

1. Introduction and Background Literature

A large number of studies on second language acquisition demonstrates that L1 interferes in L2 acquisition (Best, 1994, 1995; Eckman, 1977, 1991; Lado, 1957). There is also vast literature available on innate ability of learners to acquire a language and the time period after which the same ability declines, diminishes or thoroughly terminates (Lenneberg, 1967; Patkowski, 1990; Scovel, 1988). Feature model (FM) addresses the question whether problems in adult L2 acquisition are due to inaccessibility of learners to Universal Grammar (UG) or it is because of interference of L1? The feature model was developed by Brown (1998, 2000). The model explains with empirical evidence the way L1 feature geometry influences L2 learning.

Perceptual assimilation model (PAM) by Best (1995) is another model of perception of new sounds of a language. Whereas the FM is based on phonological features, the PAM relies on acoustic cues for perception. Another difference between the two models is that the former mainly classifies new sounds into two categories, namely those which can be easily perceived and acquired by learners but the former classifies new sounds into several different categories. The FM only categorically divides sounds into easy and difficult at large scale, but PAM provides a directionality of difficulty for listeners. In the following section phonetic perception of participants of this study has been discussed and analyzed in the light of these two models. The major difference between phonetic and phonological perception test is that in the former the abstract meaningless phonetic material is used as stimuli but in the latter meaningful words of the target language are used as stimuli.

According to the feature model (FM), children are born with innate ability to acquire language. For the FM, the UG is actually the innate ability of learners to perceive and acquire a language. A major difference between L1 and L2 acquisition is that L1 is acquired when the ability of learners to perceive phonetic material is at its peak whereas with the passage of initial some months that natural ability to perceive sounds universally diminishes because learners start acquiring phonology of L1 during this time (Werker & Tees, 1984). Thus, after the age of approximately nine months, the universal ability of babies to perceive phonetic nature of sounds diminishes but at the same time, ability to perceive phonemes of the L1 increases. Thus, after acquisition of L1, all linguistic material is filtered through the funnel of the L1. For Brown, it is the L1 feature geometry which filters new L2 sounds. If listeners receive a new pair of similar sounds of an L2 which does not have corresponding phonemes in the L1, they consider such a pair as new sounds and resort to the UG for acquisition of these sounds. According to Brown, since learners have accessibility to the UG throughout life, they can acquire such a pair of sounds. However, the sound contrasts which L2 learners have to acquire may be divided into two types. First, if a pair of new sounds is differentiated on account of a feature which is active in the L1 feature geometry, the listeners will perceive a difference in the contrast but if the same feature is not active in the L1 feature geometry, the sounds are assimilated to the closest L1 sounds because the learners will not be able to perceive the difference in the contrast and will consider them as the same sounds.

Thus, learner's L1 either impedes or facilitates the process of acquisition of a second language. In the literature, it is called negative or positive transfer respectively. The feature model explains how this process occurs. According to the model, problems in acquisition of a second language are due to defective input or learning mechanism but not because of inaccessibility of learners to the UG. The presence of L1 at the time of acquisition of L2 is one of the biggest factors which influence L2 acquisition. Different theories of first language interference have been given in the past which illustrate the mechanism which is adopted in the interference. For example, Transfer Hypothesis (Whote, 1987) claims that learners transfer parameters of grammar of L1 to L2 but the Fundamental hypothesis (Bley-Vroman, 1990) claims that only those aspects of L2 which are manifested in L1 are acquired easily. Both these echo contrastive analysis hypothesis (Lado, 1957).

Brown (1998) demonstrates that the feature geometry of L1 changes the input that the learners intake. Thus, she differentiates between *input* and *intake*. Input is what is available to a learner but intake is what a learner perceives or in the words of Brown, what the learners' feature geometry allows him/her to perceive. According to Brown, for accurate acquisition, besides accessibility to the UG, proper intake is also required. If a learner is sensitive to a specific feature of L2 sounds, s/he perceives these sounds accurately but if the learner is insensitive to a specific feature which contrasts two new L2 sounds, s/he cannot perceive those sounds accurately. According to Brown, a learner is only sensitive to a new contrast if the feature required to differentiate the contrast is already active in the L1. In that case, a new sound pair can be acquired but if the required feature which discriminates between the phonemes of the L2 target pair is not active in the L1 feature geometry, the learners remain insensitive to the contrast and perceptually assimilate the two new sounds. Brown provides empirical evidence from her studies with Japanese, Chinese and Korean learners that they can perceive only those new contrasts of English for which the required feature is active in the L1; but those new contrasts which are differentiated on the basis of the features which are inactive in the L1, could not be perceived by the participants of her experiments accurately.

In this way, the FM is the first model which very scientifically explains how L1 facilitates or impedes L2 acquisition. It very clearly divides new L2 sounds into those contrasts which can be easily perceived and acquired by L2 learners and those contrasts which cannot be perceived accurately by L2 learners. Those sounds which cannot be perceived by L2 learners also cannot be acquired by them properly. Thus, inability of adult learners to acquire a specific contrast is because of improper input but not because of inaccessibility to the UG. In this way, the feature model categorizes new L2 sounds into those which are expected to be easier and those which are expected to be difficult to learn.

One of the major possible objections to the FM is that it provides a bigger generalization about directionality of difficulty faced by learners. It categorically divides L2 phonemes into easy and difficult on account of the L1 of learners. It does not account for gradient difficulties between new phonemes. There may be sound pairs which all are differentiated on the basis of phonological features which are (in) active in the L1. For such situations, the FM does not provide a directionality of difficulty. Another objection against the FM is that it is only based on experiments conducted by Brown herself (Larson-Hall, 2004). It is only developed on account of the experiments conducted by Brown herself with only speakers of some East Asian languages. It still lacks independent empirical evidence from learners of different languages of the world.

Perceptual Assimilation Model (PAM) is another model of second language acquisition which claims that naive listeners (Best, 1994, 1995) and adult L2 learners (Best & Tyler, 2007) perceive new sounds in terms of L1 phonetic categories. If they perceive two new L2 sounds as correspondent of two different L1 sounds, they can easily discriminate such a pair of new L2 sounds. But if they perceive two L2 sounds as equally good or poor exemplar of a single L1 sound, they find it extremely difficult to discriminate such a pair of L2 sounds. The former are called Tow-Category (TC) type and the latter Single-Category (SC) type of sounds in the PAM. In some contexts, there is one sound in the L1 corresponding to two L2 sounds but one of these is perceived as a poor and the second a good exemplar of the corresponding L1 sound. Such a pair of sound is called Category-Goodness (CG) type of sound pair in the PAM. According to the directionality of difficulty developed by the PAM, TC type of sounds are the easiest and the SC type are the most difficult to perceive for naive L2 learners. CG type of sounds lie in between TC and SC type of sound pairs in terms of difficulty. This is directionality of learning of new L2 sound pairs developed by the PAM.

If one of a pair of L2 sounds is considered by the listeners corresponding to an L1 sound but another sound of the pair is not perceived as an exemplar of any of the L1 sounds, such a pair of sounds is called Categorized-Uncategorized (CU) type of sound pair. Best, predicts that on account of correspondence between one of the pair of L2 sounds with one of the L1 sounds, the discrimination between CU type of sounds may be easier. However, the difficulty or ease of discrimination also depends on how distant the two L2 sounds are from each other. There may be a pair of L2 sounds which are considered to lie out of the acoustic space of L1 phonemic inventory. Such a pair of sounds is called Uncategorized-Uncategorized (UU) type of sounds. Ease or difficulty of discrimination between such sounds depends on the phonetic distance between such sounds. However, according to the PAM, CU type of sounds are easier to discriminate than UU type of sounds. All other sounds are considered Non-assimilable (NA) sounds which according to the PAM are considered as non-linguistic or non-speech sounds. PAM does not predict about such sounds.

One of the major problems with the PAM and other models of second language acquisition is that they do not develop any scientific measure to calculate perceptual distance between two sounds (Larson-Hall, 2004). Levy (2009) attempts to solve this problem by providing a method which she calls cross-linguistic overlap method of discrimination. According to Levy, ability to discriminate new L2 sounds is in inverse correlation with the perceptual overlapping between the L2 and the corresponding L1 sounds. The more an L2 sound overlaps with the corresponding L1 sound, the more difficulty an L2 learner is expected to face in its discrimination from another sound which also overlaps with the same L1 sound. For example, if Pakistani learners perceive English [v] and [w] both overlapping with the corresponding L1 sound which is normally a labio-dental approximant, they may feel more difficulty in discrimination of English [v] and [w] consonants. This is already predicted by the PAM as the most difficult pair on account of being the single category type of sounds. However, Levy devises a statistical method to measure the level of overlap and difficulty. For example, if a group of L2 successfully discriminate between English [v] and the corresponding labio-dental approximant in only 20% of the trials and in the remaining 80% of the trials, they perceptually assimilate both sounds, and the same group of participants perceptually assimilate English [w] with the corresponding L1 sound in 70% of the trials, it means there is 70% (the lesser of the two overlaps) probability that these learners will perceptually assimilate English [v] and [w] and there is only 30% probability that they may discriminate English [v] from [w]. However, in two category type of sounds, if learners have overlapping of two new L2 sounds with the corresponding two L1 sounds, they may easily discriminate such a pair of L2 sounds. The current study aims to test these predictions with reference to acquisition of English consonants by Hindi learners.

2. Research Methodology

A group of 8 Indians living in and around London were selected for this study. Half of them were males and half females. All of them were from India (Delhi) and speak Hindi as their mother tongue. Their mean age was 23.75 (standard deviation=3.51) years. At the time of the experiment, they had stayed in the United Kingdom for 11.62 (standard deviation= 9.84) months. They claimed to listen to native English for 6-7 hours daily in average. All participants had arrived in the UK after the mean age of 22.50 (standard deviation= 1.41) years.

The stimuli for the perception test were recorded in the voice of a female native speaker of English aged 28. All target consonants were recorded in VCV format with C as the target consonant and V as low vowel i.e. [asa, awa, ava] etc. In identification test, each stimulus was played to the participants three times in random order and they were asked to identify which consonant of English they had heard. In the discrimination test, a target consonants flanked by low vowels [a] in VCV shape (e.g. [ava] etc.) was played immediately followed by two closer set of stimuli and the participants were asked to determine if the target stimulus was the same as the first or second or neither of the two later consonants. An example is quoted below to illustrate the whole process;

[awa]   [ava], [aθa]

The participants were asked to note if the consonant in the primary stimulus was the same as the first or the second consonant of the two later pair of sounds. They were asked to write 1) if the target consonant ([w] in the above example) was the same as the first ([v] in the above example) or 2) if they considered that the primary target sound was the same as the second ([θ] in case of the above example) of the later two stimuli. They were asked to write zero if neither of the later two sounds was the same as the primary target. (See the whole list and the responses of the participants in Appendix-B). The participants wrote their answers on a given sheet of paper. In this way, two possible pairs were tested in each trial. For example, in the above case, the discrimination of the participants for [w v] and [w θ] pairs was tested.

3. Presentation of results

The results of identification and discrimination tasks are presented in the following sub-sections. First, the results of identification task are presented followed by those of the discrimination task.

3.1. Identification test results

In this section, results of identification and discrimination task are given. In the identification test, VCV kind of stimuli carrying consonants of English on C position was played and the participants were asked to identify the consonant between two vowels. Each stimulus was played three times randomly. Therefore, a total of 24 (8 participants*3repetitions) responses were obtained for each consonant by the participants. The results of identification test are given in table 1.

The consonants [ʧ ʤ f s z] were included in the test as control sounds. These consonants exist in the phonemic inventory of Hindi, the L1 of the participants (Shapiro, 2007). Therefore, these consonants were not test sounds. The excellent results (87%-100%) for the control sounds confirm that the methodology used for the experiment is not defective. The results show that the participants of both groups are equally poor in identification of English dental fricatives [θ ð], approximant [w] and alveo-palatal fricative [ʒ] and it is good in perception of [v]. A non-parametric analysis run on the six target sounds confirms that the difference between sounds is strongly significant (Chi square= 19,727, p=.001).

Table 1: Identification test results

Sounds	Correct responses	Correct Percentage	Incorrect responses
ʤ	23	95.83	[k]=1
ʧ	23	95.83	[k]=1
ð	0	0	Cor= 7[z d], Lab= 17 [v w]
f	21	87.5	[s]=3
ʒ	4	16.67	Cor=19 [z j ʤ], [w]=1
s	24	100	--
w	11	45.83	[v]=13
j	16	66.67	z=04, ʤ=04
v	17	70.83	w=7
θ	1	4.167	s=17, f=6
z	23	95.83	ʤ=1

3.2. Discrimination test results

In the discrimination test, one sound was tested against two sounds. We had a total of 14 sets of stimuli; thus, participants' discrimination of a total of 28 pairs were obtained. A summary of the discrimination test results is given in table 2 below.

Table 2: Discrimination test results

S. No.	Sound Pair	accuracy(%)	S. No.	Sound Pair	accuracy(%)
1	**[ʧ] [z]**	**100**	15	**[ʧ] [z]**	**100**
2	**[s][z]**	**100**	16	**[s][z]**	**100**
3	**[s] [z]**	**87.5**	17	[z] [ð]	100
4	[s] [θ]	62.5	18	[ʒ] [j]	100
5	[z] [ð]	100	19	[ʤ] [ʒ]	100
6	[v] [z]	87.5	20	**[j] [ʤ]**	**100**
7	[v] [ð]	62.5	21	**[s] [z]**	**87.5**
8	[ð] [w]	87.5	22	[v] [z]	87.5
9	[ʒ] [ð]	62.5	23	[ð] [v]	87.5
10	[f] [θ]	37.5	24	[s] [θ]	62.5
11	[ʒ] [j]	100	25	[v] [ð]	62.5
12	[w] [v]	62.5	26	[ʒ] [ð]	62.5
13	[ʤ] [ʒ]	100	27	[w] [v]	62.5
14	**[j] [ʤ]**	**100**	28	[f] [θ]	37.5

The results highlighted bold are those of control sounds because these sounds exist in the phonemic inventory of Hindi. These consonants were not part of the set of target sounds. Excellent results for the control sounds confirm the reliability of the research methodology used in this experiment. Another important thing in the above result is that in most of the sound pairs, similar results have been obtained in repetitions. It also increases reliability of the experiment. The above table shows that the discrimination of the participants is extremely poor for [f θ] consonant pair. Most of the pairs were tested twice or thrice. These results are discussed in the following section.

4. Discussion and analysis

This section is divided into two parts. The first part is based on analysis of the results of identification test. The analysis shows that although the identification of the participants is not according to the hypotheses, but the hypotheses of the study were accurately developed in light of the predictions of PAM. The second part is based on discussion about the results obtained in the discrimination test. In this sub-section, the main discussion is on whether the findings of this study support the perceptual assimilation model or not.

4.1. Accuracy in development of hypotheses

Two tasks (identification and discrimination) were part of this experiment. The hypotheses were developed on the basis of predictions of the perceptual assimilation model. It was expected that perception of the participants would be poorer for [v] and [w] consonants compared with the other consonants. Identification test results are reflected in the following graph in percentage. The following graph reflects accuracy of participants in identification of only six target consonants. The results for control consonants are not included.

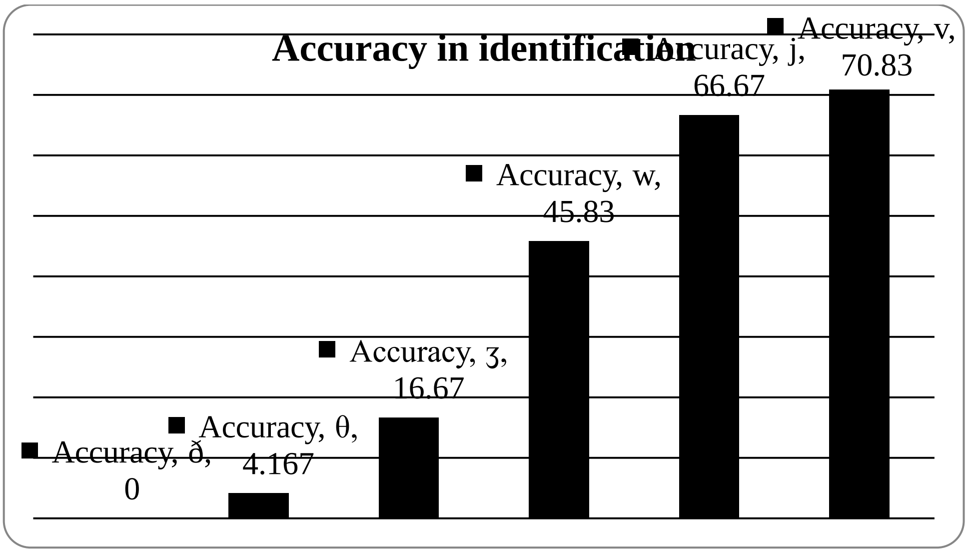

Figure 1: Identification test result (%age)

Since the perceptual assimilation model predicts poor perception for single category type of sounds and [v w] consonants were considered as single category type of consonants for the participants, it was hypothesized that participants will show poorer performance in perception of [v w] consonants. These results do not verify the hypotheses of this study. However, we must keep in mind that predictions of the perceptual assimilation model are mainly about discrimination ability of listeners. Therefore, the hypotheses of this study may be finally accepted or rejected only on the basis of discrimination test. The results of identification test can only be used to supplement the findings. Thus, we focus our attention to the discrimination test results. However, from the nature of errors committed by the participants, we can have an idea of perceptual mapping of the participants for those sounds which they cannot identify accurately. On the basis of the nature of these errors we can determine which of the target consonants lie in which category.

The results in column 4 of table 1 above shows that dental fricative [ð] is perceived by the participants either as a labial or a coronal sound. Thus it may be perceived either as [v] or [z] most probably. However, sounds identical to [v] and [z] already exist in the phonemic inventory of Hindi. Thus, in [v ð] and [z ð] sound pairs of English, one of the sounds will be ideal exemplar and the other one a poor exemplar of the L1 sounds. In this way, these sound pairs make a category goodness (CG) type of sounds for Hindi speakers. Exactly in the same way, [s θ] and [f θ] sound pairs are also CG type of sounds for these learners.

Similarly, alveo-palatal fricative [ʒ] is perceived as a coronal fricative in most of the trials. But such coronal sounds as [j z] already exist in the phonemic inventory of Hindi. In this way, [j ʒ] sound pair is also a CG type of sound pair by these participants. English [v] is misperceived as [w] and [w] as [v] by the participants of this study. But for both these sounds of English, Hindi has one corresponding sound in its phonemic inventory. In this way, [v w] sound pair is a single category (SC) type of sounds for these participants. Thus the errors committed by the participants in the identification test confirm that the categorization of sounds that we assumed on the basis of comparison of phonemic inventories of English and Hindi are correct although the perception of these sounds by the participants is not according to the expectations developed on account of predictions of the PAM. Since the predictions of the PAM are mainly about discrimination of sound pairs, we analyze the results of discrimination test to verify the predictions of the PAM in the following lines.

4.2. Testing of hypotheses

The results of discrimination task are summarized in table 2 and 3. Table 3 summarized results of repetitions in percentage. It also presents list of features involved in a sound pair and categorization of sounds according to the PAM. The features highlighted bold are inactive in the L1 (Hindi) of the participants. We can analyze these results in the light of PAM as well as FM. First we analyze the results in the light of predictions of the PAM. According to the PAM, [v w] sound pair is a single category (SC) type which is predicted to be the most difficult in the PAM. According to Flege (1995), it is almost impossible to find exactly identical consonants in two different languages. It is because there is a always some phonetic difference between two identical sounds of two different langauges. From this point of view, the consonants which exist in both Hindi and English (which were included as control sounds) may also be considered two category (TC) type of consonants. According to the PAM, TC type of sounds are the easiest to discriminate. The following table shows that all TC type of sounds are perceived most accurately by the participants in the discrimination task.

Another prediction of the PAM is that SC type of sound pairs are the most difficult to discriminate. In the current experiment, [v w] sound pair makes a SC type of sound pair. But the results show that the participants did not perform the worst in discrimination of [v w]. They rather performed worst in discrimination of [f] from [θ]. Thus we can conclude that the predictions of the PAM are partially verified in this experiment. The following directionality of difficulty is predicted in the PAM;

SC > CG > TC

About uncategorized sounds, the PAM predicts the following directionality of difficulty;

UU > UC

which means two uncategorized sounds are more difficult to discriminate than a sound pair which has one categorized and another uncategorized sound. However, PAM does not predict any directionality of difficulty which includes both above types. The results of the discrimination task are summarized in the following table. Column 4 of the table also includes the features involved in the sound pair. The features which are inactive in the L1 of the participants (Hindi) are highlighted bold.

The above results show that for almost all TC types of sounds participants have shown excellent results. The performance of the participants in discrimination of UC and UU types of sounds is also according to the prediction UU > UC. Thus two of the predictions of the PAM are verified. According to the findings of this study UC sounds are easier than UU type of sounds to perceive and TC sounds are easier than SC type of sounds to perceive. The results of the current experiment also confirm these predictions.

Table 3: Discrimination task results

S. No.	Stimuli	accuracy(%)	Features involved	Type
1	[ʧ] [z]	100, 100	voice, **distributed**	TC
2	[s][z]	100, 87.5, 100, 87.5	Voice	TC
3	[s] [θ]	62.5, 62.5	distributed, **strident**	CG
4	[z] [ð]	100, 100	distributed, strident	UC
5	[v] [z]	87.5, 87.5	PLACE	TC
6	[v] [ð]	62.5, 87.5, 62.5	PLACE	CG
7	[ð] [w]	87.5	PLACE, **round**	UC
8	[ʒ] [ð]	62.5, 62.5	anterior**, strident**	UU
9	[f] [θ]	37.5, 37.5	PLACE	CG
10	[ʒ] [j]	100, 100	**sonorant, strident**	UC
11	[w] [v]	62.5, 62.5	**round, sonorant**	SC
12	[ʤ] [ʒ]	100, 100	continuant, anterior	CU
13	[j] [ʤ]	100, 100	continuant, anterior	TC

However, the results for CG type of sound pairs are not in accordance with the predictions of the PAM. The PAM predicts CG type of sounds easier than SC but difficult than TC type of sound pairs. The above results show that some CG type of sounds proved to be easier and others difficult than TC and SC type of sounds. Actually, three CG type of sound pairs namely [s θ], [f θ] and [v ð] were part of this study. In the first two pairs, one sound in each pair, namely [s] and [f], exists in the phonemic inventory of Hindi whereas the second sound does not exist in Hindi but the listeners may perceive [θ] either as [s] or [f]. In other words, Hindi /f/ may be good exemplar of English /f/ but poor exemplar of English [θ]. Similarly, Hindi /s/ may be a good exemplar of English /s/ but a poor exemplar of English [θ]. Similar is the case for [v ð]. One of the objectives of this study was to determine a within category directionality of difficulty for learners. As pointed out in the literature review section, such a directionality is missing from the PAM and FM. Therefore, three pairs of CG type of consonants were selected in the current experiment. The results given in table 3 show that the level of difficulty in discrimination of these sound pairs for the participants is as under;

[f θ]> [s θ]> [v ð]

It means [f θ] pair of consonants is the most difficult and [v ð] the least difficult with [s θ] pair lying in between the two on the difficulty scale. English [θ] is a coronal but [f] is a labial but both have similar acoustic cues (Wester, Gilbers, & Lowie, 2007). On the other hand, English [s] and [θ] are both coronal but have relatively different acoustic cues (Simon, 2009). In other words, English [θ] is more similar to [s] in terms of feature geometry because both have coronal place but [θ] is more similar to [f] acoustically because both have similar acoustic signals. The results obtained in the discrimination test confirm that acoustic signals have more effective role in perception than phonological features. That is why [f θ] sound pair is difficult than [s θ] pair in discrimination. However, phonological features also have their role in perception. This is confirmed from the results obtained in [v ð]. Both consonants in this pair have dissimilar acoustic signals and different phonological features. Therefore, in discrimination of these consonants, the participants performed relatively better than the other two sound pairs.

These findings also support the ideas of Levy who claims that perceptual difficulty is directly proportional to overlapping of the consonants. Flege (1995) also demonstrates the same by claiming that learning of an L2 sound is in proportion to perceptual distance between the L2 sound and the corresponding L1 sound. The more dissimilar a sound is from the other closer sound, the easier it is for a learner to perceive and acquire it. Since Levy provides a statistical measure to calculate overlapping or similarity between two sounds, a meaningful directionality of difficulty for L2 learners may be developed if we calculate perceptual distance between two consonants and then predict expected difficulty for learners in perception of those sounds. Since a statistical calculation takes into account minor gradient difference between two cases, the level of difficulty can be accurately measured even between two sound pairs which lie in the same type of sounds. Thus, by joint application of Levy's statistical perceptual overlap method and PAM's predictions, we can develop meaningful and scientific generalizations about a class of L2 learners.

Now we analyze these results in the light of the predictions of the feature model. The feature model predicts that if a feature which differentiates between two sounds is active in the L1 of a group of learners, the new sound pair will be easier to perceive and acquire but on the contrary if the relevant feature is not active in the L1 feature geometry of a group of learners, the learners will not be able to acquire such a sound contrast. The FM gives a big categorical generalization about ability of learners to perceive and acquire new sound pairs. It simply predicts either a sound pair will be acquired or not by learners. In column 4 of table 3, the list of relevant features is also given against each sound pair which differentiates between the two sounds given in column 2. The features which are not active in the L1 (Hindi) of the participants of this study are highlighted in bold. Others are active in Hindi language. According to the predictions of the FM, only [ʒ j] and [v w] sound pair should be difficult for these learners but all other pairs of stimuli should be easier for these participants because, except for these two sound pairs, in each sound pair given in the list of stimuli, there is at least one feature which differentiates between the target sounds and is also active in the L1 of these participants. However, the results are quite different from what FM predicts. The participants showed 100% accurately in discrimination of [ʒ j] sound pair and 62.5% accuracy for [v w] contrast. On the other hand they should only 37.5% accuracy in discrimination of [f θ] sound pair which according to the FM they should easily discriminate because one of the sound pair is coronal by place and the other is labial and this contrast is already active in Hindi language. The FM would also predict that these participants can easily acquire [s θ] contrast because the feature [distributed] which differentiates between these two consonants is already active in Hindi. These results demonstrate that the feature model is not suitable for these learners.

5. Summary and Conclusion

The current study aimed to test the predictions of the perceptual assimilation model. It also attempted to fill the gaps found in the Perceptual Assimilation Model. Another aim of this study was to see which of the two models namely PAM and FM has stronger predictability about L2 learners. For this purpose, an identification and discrimination test was conducted with a group of 8 adult learners of English who were living in and around London. They all speak Hindi as L1. The identification test results were not according to the predictions of PAM or FM but these results confirm that the hypotheses of this study had been developed scientifically in the light of predictions of the perceptual assimilation model. For testing the hypotheses, a discrimination test was arranged. The results of the test partially confirm two predictions of the perceptual assimilation model, namely, TC type of sounds are easier than SC type of sounds and UC type of sounds are easier than UU type of sounds for discrimination. However, the prediction of the PAM that SC type of sounds are more difficult than CG type of consonants could not be verified.

The current results also provide a clue as how to measure the difficulty of learners. According to the findings of this study, phonetic cues play more effective role than phonological features in perception of adult learners. The current results also suggest that by applying Levy's statistical perceptual overlapping method, we can determine level of difficulty for sound pairs which according to the PAM lie in the same category. The current findings thoroughly reject the predictions of the feature model.

Appendix A: Actual responses of the participants in discrimination test

Stimuli				Participants' responses							
S. No.	**Focus**	**option 1**	**Option 2**	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**
1	[atʃa]	[atʃa]	[aza]	1	1	1	1	1	1	1	1
2	[atʃa]	[aza]	[asa]	0	0	0	0	0	0	0	2
3	[asaa]	[aza]	[aja]	0	0	0	0	0	0	0	1
4	[asa]	[ava]	[aθa]	2	2	2	0	0	0	1	0
5	[aza]	[atʃa]	[aða]	0	0	0	0	0	0	1	1
6	[ava]	[aza]	[aja]	0	0	0	0	0	0	1	0
7	[ava]	[atʃa]	[aða]	0	0	2	2	0	0	0	2
8	[aða]	[atʃa]	[aawaa]	0	0	0	0	0	0	0	2
9	[aʒa]	[atʃa]	[aða]	2	0	0	2	0	0	0	2
10	[afa]	[aða]	[aθa]	0	2	0	2	2	2	1	2
11	[aʒa]	[atʃa]	[aja]	2	0	2	0	0	0	0	0
12	[awa]	[ava]	[aθa]	1	0	1	0	0	0	0	1
13	[awa]	[adʒa]	[aʒa]	0	0	0	0	0	0	0	0
14	[awa]	[aja]	[adʒa]	0	0	0	0	0	0	0	0

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