Reflections on the Roles of Consonants and Vowels in Babyhood Acquisition and Speech Processing

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Abstract. Consonants and vowels play significant roles in human language systems. The roles they carried and the process they went through arise many researchers' interest. The present study reviews the research and papers about the laboring system of consonants and vowels in babyhood acquisition and language processing to find out whether consonants and vowels carry for specific works. At the same time, necessary judgment and clarification will be made to explain some experiments. At the end of this paper there found the phenomena: consonants serve more roles in the lexicon and vowels serve more roles in grammatical function. There is subconscious labor that divided consonants and vowels into different working departments according to their characteristics no matter in the early acquisition or language processing. In early acquisition, infants seek help more from consonants to build lexicon while in learning repetitive structure, they would turn to vowels more. The same results also appear in language processing: consonants, with quality distinction, show superiority in the lexicon. By contrast, vowels, with quantity distinction, show superiority in grammar. Other research conducted on brain functioning mechanisms also provides evidence that our brains process vowels and consonants differently. This paper finally concludes that vowels perform more roles in grammar and consonants perform more roles in the lexicon.

Keywords: Consonants · Vowels · Early Acquisition · speech processing · Brain function

1 Introduction

Although Consonants and vowels both belong to phonemes, there are some differences among them, such as the way we articulate them, and the way we perceive them. The difference among them may affect the way they perform in our cognitive system and our language system. For many years, many experiments have indicated that different functions of vowels and consonants perform in some respects. Nespor proposed that vowels and consonants perform different roles in our language system, and they own different characteristics which help them to achieve their task [1].

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This paper will encounter some research concerning the roles of vowels and consonants in the language. Through reviews, this paper will try to exemplify some experiments and make some judgments on some of them. In the end, this paper will be based on the research we have reviewed to find out what roles consonants and vowels carry in the process of language.

2 Vowels and Consonants in Language

2.1 Babyhood Acquisition

In babyhood, consonants and vowels act as consequential tools in language acquisition. In the following research, the specific functions that consonants and vowels perform can be verified. Nazzi and Gopnik conducted the categorization task. In this task, two phonetically different names were allocated to three dissimilar objects, and the 20-month-old infants with English-speaking backgrounds were able to put the objects with the same names together [2]. Nazzi concluded that infants at 20 months of age can distinguish two objects by relying on phonetical differences [2]. According to Werker, 17-to-20-month-old infants have been shown to own the ability to acquire two phonetically similar words at the same time [3]. The results have provided the foundation for the research of Nazzi: explore the different roles between consonants and vowels accounting for in the acquisition of new words through categorization tasks [4].

Following the categorization task, Nazzi used infants who grew up in a French-spoken environment, which was different from the previous one English, as experiment subjects and also set four groups of experiments: phonetical difference(e.g. [pize] vs [mora] Experiment 1), onset consonant difference (e.g. [pize] vs [tize], Experiment 2a), non-initial consonant difference (e.g. [pide] vs [pige], Experiment 2b) and vocalic contrasts difference (e.g. [pize] vs [pyze]; [pize] vs [paze]; [pize] vs [pizu] Experiment 3a–c) [4]. Nazzi indicated that infants could easily learn the phonetical different words and consonant different words, though to a lesser degree, while having some trouble in learning all their pairs of vocalic contrast with a percentage of chance level. The result shows that consonant and vowels did play different roles in the acquisition of new words: consonant turns out to be more important in helping infants recognize and acquire new words while vowels do not. Using French as the subject language, Nazzi's research also deals with some disputes about the effect of the proportion between consonants and vowels. French includes 15 vowels and 17 consonants, which is a rather equal ratio. Statistically, the proportion between consonants and vowels will not cause a big difference between Experiment 2a–b and Experiment 3a–c [4].

Another advantage of using French appears in the results of Experiment 2a–b. The fact that the performance shown by the infants in Experiment 2a and Experiment 2b proved not only the position will not have a significant influence on vocabulary learning but also on whether a syllable is accented or not. But on the one hand, there is a demand for more evidence and more experiment using other tasks to prove the strengthen the interpretation. On the other hand, the roles of vowels haven't been verified in this experiment.

Jean-Rémy Hochmann argued that the acquiring of language consisted of two parts: building the lexical repertoire and learning the rules that connect words into sentences

(i.e. Syntax)". Hochmann experimented with two similar paradigms to explore how consonants and vowels perform in babyhood acquisition. In two experiments, infants first heard specific words and then saw two toys appearing in two distinctive locations. In Experiment 1, infants need to acquire two words to locate toys [5]. The result turns out to be compatible with Nazzi's conclusion that infants rely more on consonants to identify words. Experiment 2 demonstrated that infants could generalize the repetitive structure with the help of vowels but not consonants [5]. These results showed that Consonants carry more lexical functions while vowels carry more syntactic functions in early acquisition. It is also can be proposed that if infants used more vowels rather than consonants while recognizing words, it would create many difficulties for them. As compared with vowels, consonants tend to be more distinctive from each other. For example, [b] and [p] are more distinguishable than [i] and [i:].

2.2 Speech Processing

Speech has played a necessary role in human society. It happens at any place and time in our daily life, in our conversations with others, in public speaking, and in the news report on the television. Consonants and vowels account for a certain function in some ways. In the following review, several research will be demonstrated to reveal the division of the labor that consonants and vowels account for in the process of speech.

Consonants and Lexicon. Saffran, Aslin, and Newport found that adults can rely only on the transitional possibilities (TP) between syllables to segment artificial sentences. That is using the TP to detect nonsense words in a continuous stream of speech [6]. Following the experiment, Peña constructed a sequence of similar speech but this time with TPs only occurring either between consonants or vowels. The results indicated that when TPs occur between consonants, subjects show the ability to recognize words in an artificial stream of speech; However, when TPs appear between vowels, subjects are unable to find words.

Also, in another experiment by Peña, subjects intend to choose TP between consonants like "dabe-pa", rather than TP between vowels like "dybo-pa". The experiment suggested that subjects would exploit consonants, not vowels to build a lexicon [7]. Here, the participants are French, a language with an almost equal proportion between consonants and vowels, excluding the possibility that the statistical gap between consonants and vowels (Malay and Italian), may cause such a distinction between them.

Another research that also investigates the roles of consonants and vowels in lexical selection was carried out by Cutler [8]. Cutler found that when allowing a change of one phoneme to make a word from a nonword, subjects tend to alter a vowel more than a consonant [8]. For example, when presented with a nonword like the kebra, the listener tends to turn it into a cobra, rather than zebra [8]. Listeners also responded faster and more accurately when required to change vowels as opposed to consonants. Thus, Culter concluded that vowels allowed more potential possibilities in the lexical selection, which means vowels carry less information than consonants do [8]. Once again, the results turn out to be compatible with what has been mentioned in Sect. 2.1, that consonants carry a more important part in lexical construction.

Nespor proposed that consonants own quality distinction and serve more to the lexicon when vowels play a role in interpreting grammar and show quantity distinction [1]. Nespor refers to one evidence was harmonization: compared with vowels, consonants tend to disharmonize with each other, which suggested that within one lexical item, consonants tend to alternate in quality [1]. For example, "knee", is pronounced as /kni:/, instead of /ni:/.

In contrast, Nespor indicated that vowels tend to harmonize through loose distinctiveness thus losing their quality. For example, unstressed vowels in English tend to centralize [1]. For example, English speakers tend to pronounce can as /kən/ rather than /kæn/ in a sequence of language. Nespor also refers to another pheromone that when deleting all the vowels from one sentence, one can still grasp some words of it from the consonants. However, when the consonants were deleted and vowels were retained, it is difficult to seize the meaning of the original sentence [1]. Nespor concluded that consonants account more for the task of distinguishing lexical items [1]. That also explains why the articulatory difference between "pig" and "big" is apparent more obvious than between "pig" and "peg". Hence, consonants serve a more lexical function. In the following part, we will take about the relation between vowels and grammar.

Vowels and Grammar. Nespor found that vowels were more likely to show quantitative distinction in one speech. In the following, we will refer to some of the research that refers to the link between the quantity characteristic of vowels and Grammar [1]. Ramus, Nespor, and Mehler found that the percentage of vowels in one speech (V%) determined the classification of rhythmic classes of one language. Grammar. Ramus, Nespor, and Mehler referred that for example, English, with vowels occupying 45% of the speech, was a stressed-timed language, Italian, with 50% of the speech, was a syllable-timed language, and Japanese, with 55% of the speech, was a mora-timed language. It has been proven by Dauer that rhythmic classes of one language were related to its grammatical proprieties like the size of the syllabic repertoire. Thus, the V% correlates with the syllabic repertoire, which says grammatical propriety. For example, as shown by Ramus, Nespor, and Mehler, a language such as Arabic and Slavic correlates with a rather rich repertoire of 6 to 8 syllabic types. Thus, vowels carry more roles in grammar through quantitative alternation [9].

Nespor argued that vowels are the main carriers of the prosodic, including stress and tone. For example, in English, stress, and tone had always been put on vowels. Hayes found that prosody help to interpret the syntax [10]. Nespor argued that the prominence provided by the vowels gives a cue to the order of the head and complements, which is compatible with the finding of Nespor and Vogel: in head-initial languages, stress is final within the phonological phrase, in head-final languages, it is initial [1] [12]. Here, head-initial languages refer to those languages with the head of a phrase preceding its complements while head-final languages refer to those with the head following its complements. The head refers to an element that determines the category of a phrase: for example, in a verb phrase, the head is a verb. Therefore, the head initial would be "VO" languages (e.g. English), and the head final would be "OV" languages(e.g. Japanese) [13]. Thus, stress carried by vowels helps to determine the order of the words according to the context. Nespor also refers to an example, in German where the orders of words

can be changed, stress given by the vowels helps to reveal the new information of the sentence. (the new information about Italian always falls in the end) [1].

Example 1: Nespor 2003 [1]
A. [Ho dato un libro a Giovanni,]!
B. [Ho dato a Giovanni un libro]!

A and B both mean I gave john a book but A Giovanni (John was new information), while B Libro (book) was new information. Sometimes, the vowel of a word being stressed can not only be new information, but also an important one that needs to be emphasized. That means people would use stress on vowels to emphasize the important part of one sentence. Collier and t'Hart found that tone and prosodic help to constitute an otherwise ambiguous sentence. Thus, it can be concluded from here that with quantity distinction, vowels carry more roles in grammar while consonants carry more roles in the lexicon through quality alternation [14].

Sentence Recognition. From Sect. 2.1 and Sect. 2.2, it seems the roles of consonants and vowels are already being determined. But there is still one research need to take into consideration. Ronald A. Cole conducted one research, different from the experiment of Peña, whose sentence in the experiment was artificial, relying on TIMT corpus [15]. Ronald found out that when all of the vowels were replaced by noise, subjects show higher accuracy than in the situation when all of the consonants were replaced by noise [15]. Here, Ronald concluded that vowels are more important for recognition than obstruent consonants [15]. Does it demonstrate the opposite conclusion to what the above research has indicated? Diane Kewley also conduct a similar experiment on young normal-hearing and elderly hearing-impaired listeners and find that vowel-remaining sentences were always more intelligible than consonant-remaining sentences. This proves the accuracy of the experiment [16].

To explain the result, two factors need to be taken into consideration: First, all the sentences were not artificial, and they came from some conversation in various contexts. That means all the original sentences have the normal grammar structure and familiar lexicon. Then subjects can recognize the altered sentence with the help of grammar, lexicon, or even between them. Thus, what vowels account for which roles cannot be determined. Second, when consonants were replaced by noise, they can still sometime be recognized as the original consonants. That's because there is some silence in the constitution of a consonant.

From the discussion above, we can conclude that vowels are more important for sentence recognition, but not clear whether they would also do some word recognition. From the research above a conclusion can be drawn that vowels account for more tasks for sentence recognition. On the basis that vowels also carry more roles in grammar, it can be proposed that humans might recognize sentences rely more on grammar rather than lexicon.

2.3 Brain Aviation for Consonants and Vowels

The reviews above show that there are different demands for consonants and vowels. There is also research that can support physical evidence of the results.

Manuel Carreiras conducted the lexical decision task in which subjects are required to read words and pseudowords in three different conditions: (i) presenting all letters simultaneously (i.e. baseline condition) (ii) presenting all letters, except that two internal consonants were delayed for 50 ms (i.e. consonants-delayed condition); and (iii) presenting all letters, except that two internal vowels were delayed for 50 ms (i.e. vowel-delayed condition). Manuel found that participants responded longer for consonants delayed sentences than in the vowels-delayed condition. In another experiment, Manuel also showed the dissociation between consonants and vowels on brain aviation. It was found that in the reading aloud task: when the vowels were changed relative to consonants, participants showed increased activation in the right middle temporal. In contrast, in lexical decision, when consonants were changed relative to vowels participants showed increased activation in the right middle frontal area [17].

These results were consistent with the claim that vowels and consonants account for different roles in language.

3 Conclusion

In sum, consonants account for more roles in the lexical area and vowels account for more roles in the grammatical area.

After reviewing the previous, one of the main findings of this paper is: that early acquisition showed that infants would rely more on consonants than vowels to build a lexicon. However, when it comes to generalizing repetitive structure, infants would seek help more from vowels rather than consonants.

Another finding of this paper is: In speech processing, there are also different demands for consonants and vowels. Consonants in one language tend to show qualitative distinctiveness and serve more in the lexicon. In artificial sentences, the transitional possibilities (TP) between consonants were shown to be more helpful for subjects than vowels in word segmenting. In another experiment, when participants were asked to change one phoneme to turn a non-word into a word, they intend to change the vowels rather than consonants. The fact that consonants tend to alter quality in harmonizing process while vowels tend to lose quality also supports the idea that consonants own quality distinction and are more important in the lexicon. When it comes to the quantity distinction of vowels, the percentage of vowels in one speech (V%) proves to be connected with rhythmic classes of one language. And the rhythmic classes of one language prove to be connected with the grammatical structure, such as syllabic repertoire. Vowels also account for the prosodic function, such as stress and tone. Stress proves to be important in determining the order of sentences in some language. The research that our brain process consonants and vowels differently also provide firm support to the disassociation roles between vowels and consonants.

References

1. M. Nespor, M. Pena and J. Mehler, "On the different roles of vowels and consonants in speech processing and language acquisition", *Lingue e linguaggio*, vol. 2, no. 2, pp. 203–230, 2003.
2. T. Nazzi and A. Gopnik, "Linguistic and cognitive abilities in infancy: when does language become a tool for categorization?", *Cognition*, vol. 80, no. 3, pp. 11–20, 2001.
3. J. Werker, C. Fennell, K. Corcoran and C. Stager, "Infants' ability to learn phonetically similar words: Effects of age and vocabulary size", *Infancy*, vol. 3, no. 1, pp. 1–30, 2002.
4. T. Nazzi, "Use of phonetic specificity during the acquisition of new words: Differences between consonants and vowels", *Cognition*, vol. 98, no. 1, pp. 13–30, 2005.
5. J. Hochmann, S. Benavides-Varela, M. Nespor and J. Mehler, "Consonants and vowels: different roles in early language acquisition", *Developmental science*, vol. 14, no. 6, pp. 1445–1458, 2011. [Accessed 26 August 2022].
6. J. Saffran, E. Newport and R. Aslin, "Word segmentation: The role of distributional cues", *Journal of memory and language*, vol. 35, no. 4, pp. 606–621, 1996.
7. M. Pena, L. Bonatti, M. Nespor and J. Mehler, "Signal-Driven Computations in Speech Processing", *Science*, vol. 298, no. 5593, pp. 604–607, 2002.
8. A. Cutler, N. Sebastián-Gallés, O. Soler-Vilageliu and B. Van Ooijen, "Constraints of vowels and consonants on lexical selection: Cross-linguistic comparisons", *Memory & cognition*, vol. 28, no. 5, pp. 746–755, 2000.
9. F. Ramus, M. Nespor and J. Mehler, "Correlates of linguistic rhythm in the speech signal", Cognition, vol. 73, no. 3, pp. 265–292, 1999.
10. R. Dauer, "Stress-timing and Syllable-timing Reanalysed", *Journal of Phonetics*, vol. 11, no. 1, pp. 51–62, 1983. [Accessed 26 August 2022].
11. B. Hayes, *Rhythm and meter*. Academic Press, 1989, pp. 201–260.
12. M. Nespor, I. Vogel, *Prosodic Phonology.* Dordrecht, Foris. 1986.
13. A. Fábregas, J. Mateu and M. T. Putnam (Eds.). *Contemporary Linguistic Parameters Contemporary Studies in Linguistics* Bloomsbury Academic. 2015.
14. R. Collier and J. Hart, *Structure and process in speech perception.* Berlin, Heidelberg: Springer, 1975, pp. 107–123.
15. R. A. Cole, Yonghong Yan, B. Mak, M. Fanty and T. Bailey, "The contribution of consonants versus vowels to word recognition in fluent speech," 1996 IEEE International Conference on Acoustics, Speech, and Signal Processing Conference Proceedings, 1996, vol. 2,pp. 853–856.
16. D. Kewley-Port, T. Zachary Burkle and J. Hee Lee, "Contribution of consonant versus vowel information to sentence intelligibility for young normal-hearing and elderly hearing-impaired listeners", *The Journal of the Acoustical Society of America*, vol. 122, no. 4, pp. 2365–2375, 2007.
17. M. Carreiras and C. Price, "Brain activation for consonants and vowels", Cerebral Cortex, vol. 18, no. 7, pp. 1727–1735, 2008.