

1. Introduction

Stops (or plosives) are a significant group of consonants that exists in all world languages (Henton, Ladefoged, and Maddieson 1992; Maddieson and Ladefoged, 1996).¹ Articulatorily, producing stops requires that the airstream in the vocal tract be totally blocked and the closure be briefly held. Once the blockage is released, the airstream behind the oral constriction suddenly escapes from the mouth. The temporal interval between the release of the constriction and the onset of vocal cord vibration is known as voice onset time (VOT) (Klatt 1975; Lisker and Abramson 1964; Zlatin 1974).² VOT has long been viewed as a reliable temporal-acoustic measure for the distinction of voicing and aspiration in stops, and can be generally classified into three categories, *voice lead*, *short lag* and *long lag*, depending on whether voicing proceeds or follows the release burst (voiced vs. voiceless) and how long the airflow release lasts (aspirated vs. unaspirated). In principle, stops are able to be uttered in any places in the vocal tract, but they tend to cross-linguistically occur in three common places: bilabial, alveolar, and velar (Gamkerlidze 1978; Maddieson 1984).

The current study has three purposes. First of all, this study aims to investigate VOT and its variation of syllable-initial stops in Hakka. Due to the universal existence of stops, and the convenient assess and great progress of modern technology in acoustic analysis, a great body of literature has been conducted to investigate the VOT issues in recent decades, such as (1) cross-linguistic surveys (e.g., Cho and Ladefoged 1999; Keating, Linker, and Huffman 1983; Shimizu 1996; Wu 2009), (2) language-specific research (e.g., Cho, Jun, and Ladefoged 2002; Docherty 1992; Gósy 2001; Han and Weitzman 1970; Helgason and Ringen 2008; Kong, Beckman, and Edwards 2011; Nielsen, 2011; Ögüt et al. 2006; Riney et al. 2007; Ringen and Suomi 2012; Rosner et al. 2000; Williams 1977), (3) second and foreign language teaching and learning (e.g., Antoniou et al. 2011; Chao and Chen 2008; Chao, Khattab, and Chen 2006; Chung 2010; Flege and Eefting 1987; Hazan and Boulakia 1993; Kang and Guion 2006; Kehoe, Lleó, and Rakow 2004; Khattab

¹ For possible reasons for the cross-language existence of stops, see Ran's (2008, 67-70) explanations.

² Besides VOT, other acoustic characteristics for distinguishing stops in different places of articulation (PoAs) are spectral peaks of the release bursts, formant transitions and silent periods. Stops in different PoAs will have their spectral energies centralized in different frequency ranges: bilabials (500~1500 Hz), alveolars (over 4000 Hz) and velars (1500~4000 Hz) (T. Lin and Wang 2005; Tsao 1996; Wu and Lin 1989). Likewise, stops of different PoAs have an influence on the formant transitions of the following vowels (Wu and Lin 1989). As for silent gaps, they are the indispensable ingredient for stops and crucial element for perceiving stops (Liang 2001; Ren 1981). In general, the lengths of stops' silent periods correspond inversely to their PoAs. To be specific, the more posterior the stop's PoA is, the shorter the silent period will be. For detailed discussion, refer to Ran (2008).

2000; Liao 2005; Ogasawara 2011; Riney and Takagi 1999; Simon 2010; Thornburgh and Ryalls 1998; Yavaş and Wildermuth 2006), and (4) clinical and pathological practice (e.g., Auzou et al. 2000; Baker et al. 2007; Fischer and Goberman 2010; Jäncke 1994; Khouw and Ciocca 2007; Liu et al. 2007, 2008; Ng and Wong 2009; Ringen and Suomi 2012; Tseng 1994; Tsui and Ciocca 2000). Despite the wide research, most of the literature concentrated on western languages (e.g., English and French). Comparatively, little attention is guided to Chinese dialects / varieties.³ For this reason, this study is specific to Hakka, with an aim to complementing the paucity of Hakka VOT studies.

The second purpose of this study is to decide the exact VOT categories to which Hakka stops belong. There are six voiceless stops in Hakka, appearing in three places (bilabial [p, p^h], alveolar [t, t^h], and velar [k, k^h]), and in two manners (unaspirated vs. aspirated). These stops are cross-linguistically common, but a systematic, large-scale investigation of the VOT variation is still in urgent demand for the following reasons. First, it is broadly reported that VOT varies under many affecting factors (see section 2 for a review). Yet, how these factors influence the VOT production in Hakka stops is scarcely examined, let alone their extent and interaction.⁴ Second, VOT varies across languages, falling into types along the VOT continuum on a language-particular basis. Cho and Ladefoged (1999), for example, separate voiceless unaspirated and aspirated stops into four

³ Mandarin Chinese seems to be an exception. A considerable amount of research (Liao 2005; Peng 2009; Ran 2008; Rochet and Fei 1991; Wu 2004; Wu and Lin 1989; among others) has explored the VOT issue in Mandarin Chinese, irrespective of the small number of participants in most of these studies. In addition, on account of the worldwide popularity of learning Mandarin Chinese as a foreign or second language, there are more and more studies examining production problems of stops by comparing VOT between Mandarin Chinese and these foreigners' native languages, like English (Chao and Chen 2008; Shi and Liao 1986; Wang, Chen, and Tsai 2006), German (Wen, Ran, and Shi 2009), Japanese (Wang and Shangguan 2004), Korean (Gao 2001), Indonesian (Y.-G. Lin and Wang 2005), and so forth.

⁴ To my knowledge, few studies investigated the VOT production of Hakka stops, except Liang (2005) and Peng (2009). On the basis of southern Sixian Hakka, Liang (2005) probed the VOT production of syllable-initial stops by 20 participants (10 males and 10 females) with their ages ranging from 27 to 72. Not aiming specifically at stops' VOT, he simply provided a general VOT exploration of Hakka stops of different places of articulation, without taking other affecting factors into consideration. Peng (2009) collected 11 males' and 10 females' production of six syllable-initial stops in Sixian Hakka followed by [i, a, u], and examined the VOT variation under factors, such as place of articulation, vowel context, tone and gender. In comparison with Liang (2005), she supplied more detailed explanations of the VOT variation in Hakka stops, but there are some weaknesses awaiting improvements. First of all, similar to Liang, the age ranges of her participants were extremely wide (36–80 years old), so she was unable to take the age factor into consideration. Second, there were only 21 subjects (10 males and 11 females) taking part in her study. Third, she claimed that the participants were all native speakers of Sixian Hakka, but their residences were not clearly stated. It is well-known that Hakka is always in linguistic contact with, and is influenced by, Southern Min and Mandarin Chinese in Taiwan. This may give rise to a negative effect on VOT. For this reason, this study will recruit participants inhabiting in Miaoli County, the most intensely populated area by speakers of (northern) Sixian Hakka. Hakka is also the daily language used by these people recruited in this study, so the homogeneity of the participants can be ensured, and the reliability of the study can be guaranteed.