Pitch span or pitch register? Exploring iconicity and gender through the Effort Code

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Pitch has long been claimed to have iconic associations, which influence pitch meanings [1,2]. While the Frequency Code is well known (association of pitch level with body size), there has been less attention to other associations, such as the Effort Code, i.e., association of greater articulatory effort with greater arousal and meanings like surprise or importance [2]. While previous research has shown pitch meanings consistent with the Effort Code [2-4], to our knowledge, no work has looked at the association with physical effort itself said to underlie this Code. We test this association, and examine two interesting questions in relation to it. Firstly, the Effort Code and Frequency Code should relate to different kinds of pitch variation: the Effort Code to *pitch span*, i.e. the size of the pitch excursion, which links to articulatory effort; and the Frequency Code to *pitch register*, i.e. the overall pitch height, which links more to inter-speaker differences. However, in practice listeners have been shown to be variable in how this is applied, e.g. [3] found British English and Dutch listeners associated *emphasis* with higher pitch span, but Dutch also with higher register. We test if physical effort is associated with only pitch span, or also register. Secondly, recent work has shown that the strength of iconic pitch associations differs between listeners according to their beliefs, experience and language [5-7]. For example, Frequency Code associations are stronger for men and male voices, given stronger gender stereotypes relating to the Frequency Code for these groups [6]. For the Effort Code, there is a potential relationship to cultural stereotypes around women showing greater effort, e.g. being more helpful [8]. For example, [9] showed dramatic pitch movements are associated with greater charisma, particularly for female speakers. We test if effort-pitch associations are stronger for female speakers.

Online Implicit Association Tasks (IAT, [10]) were run with 129 English speaking participants (65 female, 64 male, median age 29 years). Participants categorised low and high pitch stimuli (nonce words with resynthesized pitch) and stick figures portraying activities involving less or more effort (e.g. *resting* vs. *running*). Participants used either the same response key for low pitch/less effort and for high pitch/more effort (consistent block), or opposite keys (inconsistent block). An implicit association is shown if RTs are faster in the consistent than inconsistent block. There were four versions of the IATs, with either pitch register or pitch span variation, and either male or female voices.

A Linear Mixed Effects (LME) model was built to predict RTs for correct responses (accuracy 95%, N= 11,739). RTs were inverse square root transformed. The final model is in (1). We gauged the effect of consistency through its interaction with other fixed effects, rather than using standard IAT D-scores [10], as these involve data reduction (see [11]). There was a significant effect of consistency ($F(1,124.6)=22.8$, $p<0.0001$, N=11,739), showing listeners implicitly associated high pitch with more effort and low pitch with less effort, consistent with the Effort Code. As shown in Figure 1, this association held for pitch span but not pitch height ($F(1,124.5)=21.8$, $p<0.0001$). That is, listeners are sensitive to the type of pitch variation with the Effort Code, only associating pitch span with effort. As Figure 2 shows, associations were stronger for female voices than male ($F(1,135.6)=3.93$, $p=0.0494$). This shows the predicted effect of gender given stereotypical associations of women with helpfulness. There was no effect of participant gender or age.

These results show for the first time that listeners associate pitch span and physical effort, in line with the Effort Code. This validates this sound symbolic source of pitch meaning, opening possibilities for further research. We have also shown that while iconic associations provide an extra-linguistic source of meaning, their strength and availability differ by listeners' experiences and beliefs. In particular, gendered beliefs interact in complex and interesting ways with the Frequency and Effort Codes as sources of pitch meaning.

(1) *Final model:* response time ~ consistency + consistency:pitch condition + consistency:voice gender + consistency:order + stimulus type + stimulus type:participant age + (1 + consistency | participant) + (1 + consistency + participant gender | stimulus)
(*where order is whether the consistent block was presented before the inconsistent or vice versa, and stimulus type is whether the stimulus was voice or picture).*

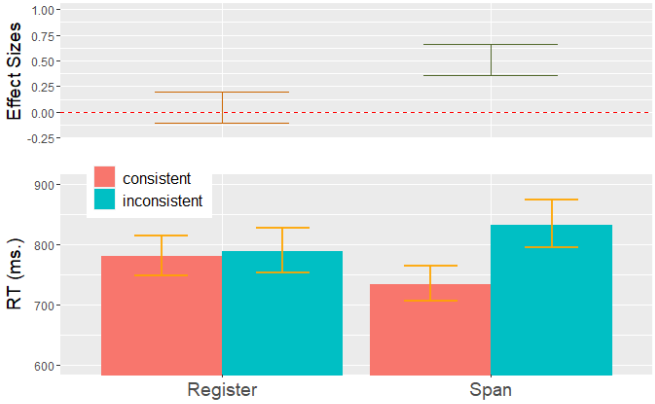

Figure 1: model estimates of the effect of consistency and pitch condition on response times. Bottom panel shows response times. Top panel shows the effect size for the difference between consistent and inconsistent blocks (0 is no significant effect).

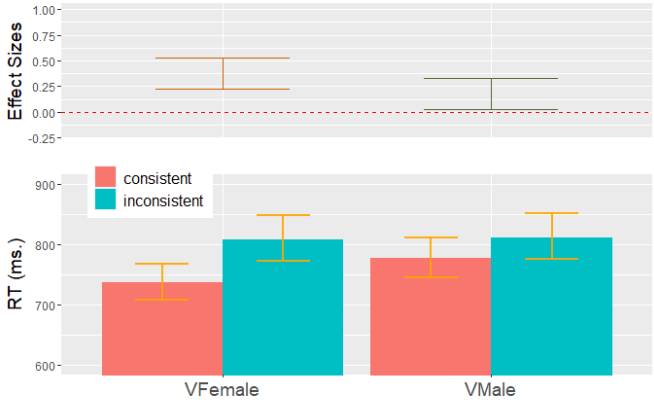

Figure 2: model estimates of the effect of consistency and voice gender on response times. Bottom panel shows response times. Top panel shows the effect size for the difference between consistent and inconsistent blocks (0 is no significant effect).

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