Are Precues Effective in Proactively Controlling Taboo Interference During Speech Production?

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Abstract

This research investigated whether precues engage proactive control to reduce emotional interference during speech production. A picture-word interference task required participants to name target pictures accompanied by taboo, negative, or neutral distractors. Proactive control was manipulated by presenting precues that signaled the type of distractor that would appear on the next trial. Experiment 1 included one block of trials with precues and one without, whereas Experiment 2 mixed precued and uncued trials. Consistent with previous research, picture naming was slowed in both experiments when distractors were taboo or negative compared to neutral, with the greatest slowing effect when distractors were taboo. Evidence that precues engaged proactive control to reduce interference from taboo (but not negative) distractors was found in Experiment 1. In contrast, mixing precued trials in Experiment 2 resulted in no taboo cueing benefit. These results suggest that item-level proactive control can be engaged under certain conditions to reduce taboo interference during speech production, findings that help to refine a role for cognitive control of distraction during speech production.

Keywords: *speech production, taboo interference, proactive control*

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Imagine engaging in a conversation when strangers pass by using vulgar, i.e., taboo, words in their discourse. Because taboo words attract attention (Harris & Pashler, 2004), inhibiting the taboo speech can be difficult and likely temporarily interferes with your own conversation. In order to minimize interference from this type of distraction on discourse, speakers must be able to invoke some type of cognitive control. Previous research suggests that cognitive control helps mobilize attention to control behavior: *Reactive control* is stimulus-driven and resolves interference after it is detected, whereas *proactive control* anticipates interference in order to prevent or minimize it (Braver, 2012). In the above example, the unexpected nature of the taboo words requires reactive control of the distraction after it is detected so that interruptions to one's own speech can be resolved. In contrast, if the vulgar speaker was instead a friend frequently known to use taboo words, the distraction could be predicted and proactively controlled before speech is disrupted. These control mechanisms are commonly investigated using attention tasks such as the Stroop color naming task (Stroop, 1935), where engaging proactive control reduces Stroop interference that is typically regulated by reactive control, but only under certain conditions (Bugg & Smallwood, 2016; Goldfarb & Henick, 2013). However, how proactive and reactive control might regulate distraction when speaking is unknown, despite awareness that various distractions inhibit speaking (e.g., Becic, Dell, Bock, Garnsey, Kubose, & Kramer, 2010). Therefore, the aim of the present research was to understand the nature of cognitive control in language production. We focused on cognitive control of emotional distractors, particularly taboo words, which draw attention away from word production and consequently slow speech (e.g., Dhooge & Hartsuiker, 2011; White, Abrams, LaBat, & Rhynes, 2016; White, Abrams, Koehler, & Collins, 2017).

Research investigating emotional interference during speech production has used a picture-word interference (PWI) task, where a to-be-named picture is presented in the presence of a distractor word. Pictures are named slower when accompanied by taboo compared to neutral distractors (Dhooge & Hartsuiker, 2011; Hansen, McMahon, Burt, & de Zubicaray, 2017; White et al., 2016, 2017), an interference effect which also occurs to a lesser degree with highly-arousing negative distractors (White et al., 2016). Explaining the interference from emotional distractors during PWI within existing theoretical models of speech production has been a challenge because these theories were designed to account for linguistic sources of interference. White et al. (2016) attempted to accommodate emotional interference effects into existing mechanisms within the WEAVER++ model (Roelofs, 2003). Specifically, they postulated that reactive blocking, a type of reactive control, takes longer when distractors are strong emotional words because of difficulty disengaging from their highly-arousing properties. However, an alternative (and possibly more parsimonious) approach to explaining the regulation of emotional interference while speaking is to implicate domain-general control mechanisms that are not specific to speech production (Piai et al., 2013). One example of such a domain-general approach is the Dual Mechanisms of Control framework (Braver, 2012), which postulates that interference can be regulated by reactive control (similar to reactive blocking in WEAVER++) as well as proactive control.

Research suggests an important role for cognitive control in resolving conflict among language representations (e.g., Abutalebi & Green, 2007; Badre & Wagner, 2007; Moss Abdallah, Fletcher, Bright, Pilgrim, Acres, & Tyler, 2005; Novick, Trueswell, & Thompson-Schill, 2005; Rodriguez-Fornells, De Diego Balaguer, & Münte, 2006). Although findings from these studies indirectly suggest a role for reactive control in reducing interference during language processing, research has yet to specify a role for proactive control. In contrast, recent research is starting to identify the conditions under which proactive and reactive control are engaged to regulate interference in Stroop tasks (e.g., Bugg & Smallwood, 2016; Bugg, Diede, Cohen-Shikora, & Selmeczy, 2015). Much of this research has focused on two well-documented effects that are known to *reduce* Stroop interference: The *list-wide proportion congruence* effect occurs when the majority of trials within a block or list of items are incongruent vs. congruent, and the *item-specific proportion congruence* effect appears when specific items (e.g., the word red) appear as incongruent in the majority of trials within a task block (e.g., Bugg, Jacoby, & Toth, 2008; Logan & Zbrodoff, 1979). The list-wide proportion congruence effect is thought to reflect a proactive biasing of attention away from the irrelevant dimension (the words) for the entire block of trials (De Pisapia & Braver, 2006), whereas the item-specific proportion congruence effect arises when an item (or feature of an item) signals the need for reactive control (Bugg et al., 2008). Taken together, these effects support the Dual Mechanisms of Control framework, where reactive and proactive mechanisms are dissociated and not simply two ends of a continuum (e.g., Braver, 2012; Gonthier, Braver, & Bugg, 2016).

The list-wide and item-specific proportion congruence effects occur without any intentional engagement of cognitive control mechanisms. Recently, researchers have demonstrated that proactive control can be *intentionally* engaged through visual precues that indicate whether the forthcoming Stroop trial is congruent or incongruent (Bugg & Smallwood, 2016; Goldfarb & Henik, 2013; Hutchison, Bugg, Lim, & Olsen, 2016). On incongruent trials, the precues allow participants to anticipate upcoming interference and engage a strategy (i.e., ignore the word) to reduce that interference. Importantly, research has shown that the effectiveness of precues to proactively direct attention away from word reading depends on certain conditions. One condition identified by Bugg and Smallwood (2016) is “stimulus uncertainty”, defined in Stroop tasks as whether color-word pairings are predictable. Color-word pairings are easily predicted in a block of trials when each word (e.g., red) is only paired with its congruent color and one incongruent color (e.g., yellow), whereas color-word pairings cannot be predicted when print color and word are uncorrelated. Bugg and Smallwood found that proactive control from precues was not engaged for predictable color-word pairings, as these pairings allowed participants to reactively switch attention to the word dimension on incongruent trials and use the word to predict its associated color. In contrast, when color-word pairings were unpredictable, precues induced proactive control, allowing participants to anticipate upcoming interference from incongruent trials and engage a strategy (i.e., ignore the word) to reduce that interference. A second condition demonstrated by Goldfarb and Henik (2013) is the likelihood of conflict (i.e., incongruent trials) in an experimental list: When the probability of encountering an incongruent trial was high (50% of trials are incongruent), there was no benefit of precues in reducing Stroop interference. In contrast, when the probability of an incongruent trial was low (20%), precues were effective in reducing interference. Finding no benefit of precues in high conflict lists suggests that participants applied a global proactive strategy (to always ignore the word) to all trials, reducing the benefit of item-level proactive control that is provided by precues.

Taken together, results from previous research using precues to reduce Stroop interference suggest that item-level proactive control can be effectively engaged through precues, although it may be limited to situations where interference is not effectively regulated by reactive control alone or by a global proactive strategy applied to all trials. Broadly, the Dual Mechanisms of Control framework maintains that reactive control should be preferred over proactive control because of the demand that goal maintenance places on limited attentional resources (e.g., relying on sustained activity in the lateral prefrontal cortex; Braver et al., 2007). However, when interference is strong and reliably predictable, proactive control may be recruited to assist reactive control, as seen with the engagement of global proactive control during Stroop naming of mostly-incongruent lists. Because global proactive control likely requires sustained resources to maintain a goal throughout an experimental list, item-level proactive control should allow the brain to conserve limited resources (Goldfarb & Henik, 2013).

The emotional PWI task provides a unique opportunity to investigate item-level proactive control through precues in speech production. The PWI task ensures stimulus uncertainty on each trial, a condition that enhances reliance on precues to reduce Stroop interference (Bugg & Smallwood, 2016). In the PWI task, both the distractor type (e.g., taboo, negative, or neutral) and the actual distractor word (e.g., shit, grave, tree) are uncertain on each trial. When trials are uncued, reactive control is required to respond to both levels of uncertainty. Precues can remove one source of uncertainty (the distractor type) by indicating the type of distractor (e.g., taboo) that will appear, therefore shifting some of the responsibility for regulating distractor interference from reactive to proactive control (Gonthier, Braver, & Bugg, 2016; Hutchison et al., 2016). Although the mechanisms that allow proactive and reactive control to reduce interference are unknown (Geng, 2014), precues could signal enhanced processing of the target picture or suppression of distractors (Geng, 2014; Grimshaw, Kranz, Carmel, Moody, & Devue, 2017).

Furthermore, the extreme nature of taboo interference provides an ideal situation to test the effectiveness of precues, as taboo words are known to attract attention (Bertels, Kolinsky, Pietrons, & Morais, 2011) and significantly impair picture naming (e.g., White et al., 2016, 2017). Thus, taboo distractors are prime candidates for cueing because their interference effects satisfy one condition that encourages proactive control according to the Dual Mechanisms of Control framework, i.e., that the interference effects are “large and costly (in terms of performance)” (Braver et al., 2007, p. 90). Because list-level (global) proactive control is reduced (Goldfarb & Henik, 2013) or eliminated (Hutchison et al., 2016) when precues are presented in a Stroop task, we anticipated that precues would reduce reliance on global proactive control to minimize the effect of distractors in PWI. Selectively engaging proactive control for individual trials should also be more efficient than maintaining a goal (e.g., always be on the lookout for a taboo word) for an entire list of experimental items, particularly when the majority of distractors (e.g., neutral) do not produce strong interference.

In addition to extending research on proactive control to speech production, the present study extended research on cognitive control of distractors to emotional words. Much of our current understanding of precues and proactive control is informed by studies that use emotionally-neutral words (e.g., Bugg & Smallwood, 2016; Goldfarb & Henik, 2013; but see Grimshaw et al., 2017, for an exception), which may differ from emotional words in their control demands (e.g., Etkin, Egner, Peraza, Kandel, & Hirsch, 2006; Soutschek & Schubert, 2013). Furthermore, research investigating proactive control of emotional stimuli has primarily focused on visual stimuli, i.e., emotional faces or pictures, and has revealed mixed evidence. For example, Krug and Carter (2012) showed reduced emotional interference in a list-wide proportion congruence emotional facial Stroop task, whereas Kleinsorge (2007) found that interference from negative emotional pictures on math performance was greater following precues compared to no cues. We know of no studies that have investigated the use of cues to regulate interference from strong emotional words, and specifically taboo words.

Experiment 1

Experiment 1 investigated whether precues reduce interference from emotional distractors in the PWI task. We varied the type of distractor presented on each trial (taboo, negative, or neutral) and the presence of a precue (whether the trial was precued or uncued). Because taboo distractors lead to significant disruption in picture naming (slowing picture naming by as much as five times that of negative distractors; White et al., 2016), we predicted that taboo trials would show the greatest cueing benefit, i.e., less interference on precued vs. uncued trials. In contrast, relatively little reactive control is required to respond to neutral distractors regardless of the presence of a cue. Following from the suggestion that resources are reserved for high conflict conditions (Goldfarb & Henik, 2013), it would be inefficient to expend resource-consuming proactive control under low-conflict conditions (i.e., neutral distractors). Thus, we predicted no cueing benefit for neutral trials since interference from neutral distractors can easily be reactively controlled. We also included negative distractors because they have been shown to interfere with picture naming relative to neutral distractors, although to a smaller degree than taboo distractors (White et al., 2016). Therefore, including both taboo and negative distractors allowed us to determine whether precues have a benefit for emotionally-interfering trials more generally, or only on the most interfering, taboo trials.

Method

Participants

To ensure sufficient power to detect interference, we first reviewed previous PWI studies and their effect sizes (e.g., Dhooge & Hartsuiker, 2011; White et al., 2016). We then estimated our sample size based on repeated measures design using G-power (Faul, Erdfelder, Lang, & Buchner, 2007). We collected 60 total participants, which ensured 95% power to detect a small effect size (e.g., .20-.25). These 60 participants were native English-speaking undergraduates (42 females; *M* = 19.2 years old, *SD* = 1.4) who did not report learning disabilities (dyslexia or ADD/ADHD) participated in exchange for partial course credit.

Materials

Target Pictures. Thirty target pictures were selected, with no more than four targets from one semantic category (e.g., animals). Target pictures were 3.5” x 3.5” black drawings on a white background, chosen from Google images.

Distractors. Each target picture was assigned three distractors: one taboo, one negative, and one neutral (see Appendix). Taboo distractors were selected from taboo norms (Janschewitz, 2008), whereas negative and neutral distractors were selected from Warriner, Kuperman, and Brysbaert (2013) norms. Confirming the differences in valence and arousal between the three distractor types, negative distractors were significantly more negative in valence than taboo distractors, which were more negative than neutral distractors (ps < .004). Taboo distractors were also more arousing than negative distractors, which were more arousing than neutral distractors (ps < .041). Finally, taboo distractors had higher tabooness ratings than negative distractors, which had higher ratings than neutral distractors (ps < .001). Importantly, however, the three distractor types did not differ in SUBTLEX word frequency (Brysbaert & New, 2009), word length, phonological neighborhood, or mean bigram frequency (Balota, Yap, Cortese, Hutchison, Kessler, et al., 2007), ps > .25 (see Table 1).

Distractors were presented in bolded, 22 point, black Arial font. The location of the distractor varied such that on each trial, the distractor's horizontal position was randomly selected to be in the center of the screen, 500 twips to the left of center, or 500 twips to the right of center. Similarly, the distractor's vertical position was randomly chosen to be in the center, 500 twips above the center, or 500 twips below the center.

Fillers. Thirty filler pictures were included to reduce carryover effects from taboo target trials (White et al., 2016). Unrelated, neutral (M_{valence} = 5.70) distractor words were presented with filler pictures.

Procedure

Participants consented to participate knowing that some trials would contain taboo words. Participants were then familiarized with the appropriate names for each picture. Each target and filler picture was randomly presented (without any distractor), and participants were asked to name each picture. Any picture that was incorrectly named was re-presented until the correct picture name was produced.

The PWI trials were divided into two blocks, one with precues and one without precues. Each block consisted of 90 pictures, half of which were 15 targets presented with each of their three associated distractors (taboo, negative, or neutral) and 15 fillers presented three times. Within each block, pictures were counterbalanced so that each picture was named with one distractor type before being re-presented with a different distractor type. Target pictures were counterbalanced across blocks, and block order was counterbalanced across participants such that half first named pictures without precues, whereas the other half first named pictures that were precued. Each target picture was followed by a randomly-selected filler picture.

The *uncued block* instructed participants that they would see a black fixation (+) followed by a picture and distractor, and that they should name the picture as quickly and accurately as possible while ignoring the distractor word. Participants completed five practice trials, followed by 90 alternating target and filler trials.

The *precued block* instructed participants that the fixation would be colored red, green, or blue, and each color would correspond to the type of distractor word that would appear next on the screen (e.g., a blue fixation would signal the appearance of a taboo word). Cue colors were counterbalanced across participants so that taboo distractors were associated with each color type (red, green, and blue). Prior to the PWI trials, participants engaged in a learning phase to ensure they associated each color with its respective distractor type. During this learning phase, participants saw a color fixation for 1000 ms, followed by the associated word “taboo”, “negative”, or “neutral” for 2000 ms. There were 15 of these learning trials, showing five of each fixation-distractor type in random order. Participants were then tested on the learned associations: They were presented with each color fixation and had to verbally indicate the appropriate condition for each color. Feedback was given for any errors, and participants had to get three of each type correct before moving on to the PWI trials. Participants then completed 15 practice PWI trials, five with each color precue, followed by 90 alternating target and filler trials.

The procedure for each PWI trial included a fixation (+) that appeared for 1500 ms and was immediately replaced with a picture and superimposed distractor. Distractors remained on the screen for 350 ms after onset (see Dhooge & Hartsuiker, 2011; White et al., 2017), whereas pictures remained on screen for 2000 ms. A 1500 ms blank screen followed each picture and was replaced with the next fixation.

Following the experiment, participants were asked to recall each color-distractor type pairing, and all participants reported the correct pairs.

Results

Naming times (in ms) were extracted from wavefiles using a voice onset program (Jennings & Abrams, 2018). All wavefiles were checked manually for accuracy, and naming onset times were manually coded when the program could not easily determine the onset time (45% of trials). Analyses excluded trials when a wavefile failed to record or was undecipherable, as well as when participants made speech errors, failed to respond within 3000 ms, or produced the wrong picture name (2.8%). Outliers were then calculated as naming times greater or less than 2.0 *SD* from each participant's mean, which removed an additional 4.6% of trials.

Target Picture Naming. A 2 (Cue Type: Precued, Uncued) x 3 (Distractor Type: Taboo, Negative, Neutral) repeated-measures analysis of variance (ANOVA) was performed on mean target picture naming times by participant (F_1) and item (F_2). Because our participant analyses were more powerful than item analyses, effects were only interpreted when participant analyses were significant. Each naming time was first converted to a z-score in order to account for variability in naming time (Faust, Balota, Spieler, & Ferraro, 1999). However, analyses on raw naming times (in ms) replicated the z-score analyses, and naming times in ms are presented in tables and figures for ease of interpretation.

The main effect of distractor type was significant, F_1 (2, 118) = 96.82, *MSE* = .12, p < .001, η_p^2 = .62, F_2 (2, 58) = 101.26, *MSE* = .05, p < .001, η_p^2 = .78, with taboo distractors (M_1 = 996) producing slower naming times than negative distractors (M_1 = 909), which produced slower naming times than neutral distractors (M_1 = 871), *p*s < .001. The main effect of cue type was not significant, F_1 (1, 59) = 2.33, *MSE* = .19, p = .13, η_p^2 = .04, F_2 (1, 29) = 7.33, *MSE* = .04, p = .01, η_p^2 = .20. The Cue Type x Distractor Type interaction was significant, F_1 (2, 118) = 3.58, *MSE* = .07, p = .03, η_p^2 = .06, F_2 (2, 58) = 4.24, *MSE* = .02, p = .02, η_p^2 = .13 (see Figure 1). Relative to trials without precues, significant speeding from precues occurred when distractors were taboo (p_1 = .01, η_p^2 = .10, p_2 = .004, η_p^2 = .25) but not when distractors were negative (p_1 = .77, η_p^2 = .001, p_2 = .81, η_p^2 = .002) or neutral (p_1 = .74, η_p^2 = .002, p_2 = .13, η_p^2 = .08).

Discussion

This experiment supported the prediction that precues engage item-level proactive control and reduce taboo interference during speech production. Finding a cueing benefit for taboo trials but not for negative or neutral trials suggests that precues assist in reducing interference from the most interfering stimuli, here extremely arousing and socially-inappropriate distractor words, by invoking item-level proactive control. However, taboo interference was not completely eliminated by the presence of precues, suggesting that reactive control is still needed to block taboo distractors. This is not surprising, given that the specific taboo distractor (e.g., “shit” or “asshole”) cannot be predicted, allowing that taboo word to engage attention upon presentation even when there is a warning that a taboo word is forthcoming. The lack of cueing on negative trials suggests that negativity is not a stimulus characteristic worth engaging proactive control, at least when there are taboo distractors in the context (see also White, Abrams, & Glidden, 2018). Relative to taboo distractors, negative distractors do not result in as much interference (i.e., slowing) in picture naming and thus may not warrant use of limited proactive control resources, consistent with the Dual Mechanisms of Control account that reactive control will be used when possible in order to conserve resources (Braver et al., 2007).

However, finding evidence of item-level proactive control may have been the result of relatively “optimal” conditions that were employed in this experiment. First, we included highly-interfering (taboo) distractors, a condition that is likely to invoke item-level proactive control because taboo distractors have the potential to strongly impair picture naming performance. Second, consistent with Bugg and Smallwood (2016), this experiment ensured stimulus uncertainty, as the distractor could never be predicted prior to its onset. Precues therefore reduced some of this uncertainty by indicating when a taboo distractor would appear. Third, as suggested by Goldfarb and Henik (2013), the majority of trials had low-interference (i.e., neutral) distractors, reducing the likelihood that global-level proactive control strategies would be utilized and undermine the cueing benefit. Finally, the use of a blocked design to present precued and uncued trials may have minimized demands on proactive control that have been shown when trial types are mixed (Braver et al., 2003). We chose to explore the effect of mixing cue types in Experiment 2, as previous research has not systematically investigated the effect that blocked or mixed designs has on cueing effects. Although not investigated with cue types, mixing cue-stimulus intervals has been shown to reduce cueing benefits in Stroop tasks (Bugg & Smallwood, 2016), suggesting that mixing cue types might also affect cueing in PWI.

Experiment 2

The goal of Experiment 2 was to investigate whether experimental contexts that create more uncertainty by removing the predictability of cue availability affect the use of precues to reduce taboo interference in speech production. In Experiment 1, blocking cue type provided a context in which the availability of precues was consistent, a situation that may have been favorable for the use of precues. In contrast, experimental contexts that create uncertainty, as when an independent variable (e.g., cue type) is mixed within an experimental context, limit one's ability to prepare for the upcoming trial, resulting in slower responses compared to when the independent variable is blocked (Los, 1996). It is possible that the uncertainty created in mixed contexts consumes resources that could otherwise be directed to goal maintenance or preparation for an upcoming trial. Some evidence for this notion comes from research showing that high cognitive load slows inhibition of distractors in a selective attention task (e.g., Lavie, Hirst, de Fockert, & Viding, 2004), and secondary working memory tasks reduce proactive control in Stroop tasks (e.g., Soutschek, Strobach, & Schubert, 2013).

In order to create this experimental uncertainty, Experiment 2 mixed precued and uncued trials, thereby creating a context where both cue type *and* distractor type are unpredictable prior to getting a precue. This uncertainty is likely to consume resources that might otherwise be devoted to preparing for interference on individual trials. We anticipated that the increased demands from mixing precued and uncued trials would specifically affect proactive control, thus reducing or eliminating the benefit of cueing on taboo interference. The majority of previous research using precues to regulate interference of unemotional stimuli has blocked presentation of precued and uncued trials (e.g., Bugg & Smallwood, 2016; Hutchison et al., 2016; but see Goldfarb & Henik, 2013, for an exception). Thus, our understanding of the constraints that mixing cue types might impose on proactive control, especially for emotional stimuli, is limited.

Method

Participants

Sixty participants (48 females; *M* = 18.8 years old, *SD* = 0.69) were recruited with the same requirements as in Experiment 1.

Materials

The target pictures, filler pictures, and distractors were identical to Experiment 1.

Procedure

The procedure differed from Experiment 1 in three ways. First, we replaced the color precue fixations with word cues (TABOO, NEGATIVE, NEUTRAL) in order to be more consistent with other cueing studies (e.g., Bugg & Smallwood, 2016; Hutchison et al., 2016), to reduce an unnecessary working memory load that the color fixations required, and to avoid any potential impact from preexisting color associations (e.g., red and “warning”). Uncued trials were preceded by a string of XXXXXXX. Thus, participants did not undergo the color precue learning phase and instead were told that the precue word would indicate the type of distractor that would appear on the next trial.

Second, precued and uncued trials were combined into a single experimental list. Whether a target picture was precued or uncued was counterbalanced across participants, with participants seeing an equal number of precued and uncued trials. Each target picture was presented three times, once with each distractor type (taboo, negative, neutral). The order of presentation of distractor types, as well as the type of trial (precued, uncued) for a given target picture, was selected at random.

Finally, instructions indicated that some trials would be precued and other trials would not be precued. Participants completed eight practice trials, two uncued and two with each of the three precue types.

Results

Naming times were determined in the same way as Experiment 1, with 54% of onset times manually coded. Missing wavefiles, undecipherable wavefiles, and errors made by participants were excluded from analyses (3.8 %), as were outliers (5.1%).

Target Picture Naming. As in Experiment 1, a 2 (Cue Type: Precued, Uncued) x 3 (Distractor Type: Taboo, Negative, Neutral) repeated-measures ANOVA was performed on mean target picture naming times (see Table 2). As in Experiment 1, each naming time was first converted to a z-score, and analyses on raw naming times replicated the z-score analyses. There was a main effect of distractor type, F_1 (2, 118) = 94.56, *MSE* = .11, $p < .001$, $\eta_p^2 = .62$, F_2 (2, 58) = 84.58, *MSE* = .06, $p < .001$, $\eta_p^2 = .74$, with taboo distractors (M_1 = 1055) producing the slowest naming times, followed by negative distractors (M_1 = 973), then by neutral distractors (M_1 = 928), *p*s < .001. The main effect of cue type was not significant, F_1 (1, 59) = 2.29, *MSE* =

.11, p = .14, η_p^2 = .04, F_2 < 1, η_p^2 = .002. Unlike Experiment 1, the Distractor Type x Precue Type interaction was not significant, F_1 (2, 118) = 1.62, *MSE* = .07, p = .20, η_p^2 = .03, F_2 (2, 58) = 1.64, *MSE* = .03, p = .20, η_p^2 = .05.

Discussion

Experiment 2 demonstrated that mixing precued and uncued trials reduces the benefit of cueing on taboo trials: Compared to Experiment 1 where presentation of precues was blocked and a reliable taboo cueing effect was observed, precues were not effective in Experiment 2. One explanation for the lack of cueing is that the uncertainty created by the mixed cue types places demands on cognitive control that reduce engagement of item-level proactive control, similar to findings that expecting a high working memory load results in a shift from proactive to reactive control strategy (Speer, Jacoby, & Braver, 2003). Indeed, according to the Dual Mechanisms of Control framework (Braver, 2012; Braver et al., 2007), when the ability to use proactive control is reduced, the job of managing interference from a distractor shifts to reactive control, a hypothesis which has been supported in other studies (e.g., Burgess & Braver, 2010, Speer, Jacoby, & Braver, 2003). Consequently, slowing occurs from taboo and negative distractors (replicating Experiment 1 and White et al., 2016), but this slowing is independent of whether or not a cue is present. Although the switch from color cues to word cues could potentially have reduced the cueing effect, this is unlikely because word cues are more automatically processed than color cues, which require learned associations between a color and a cue type.

General Discussion

The experiments reported here demonstrate that domain general mechanisms of cognitive control can be applied to a language task which requires regulation of distractor interference: The results provide support for the Dual Mechanisms of Control account of cognitive control that proposes two mechanisms to help govern interference (Braver, 2012). Specifically, compared to previous research showing that distractors are reactively controlled during PWI, the present research shows that under ideal conditions, proactive control can assist in reducing interference from distractors during speech production. Our experiments were designed to incorporate conditions that have been shown to effectively increase reliance on item-level proactive control in Stroop studies: stimulus (distractor) unpredictability and a low proportion of particularly interfering (taboo) trials. In addition, we tested a new condition predicted to affect cueing: the (un)certainty of cue availability. Using these three conditions, Experiment 1 demonstrated that proactive control can reduce interference through the use of precues when the distractors are highly interfering (here, taboo words) and when the occurrence of precues are reliably predictable. However, removing one of these additional factors limits the benefits of precues. In Experiment 1, precues were not effective in reducing interference when distractors produced smaller interference effects (i.e., negative distractors), and in Experiment 2, precues were not effective when precued and uncued trials were mixed rather than blocked.

Although the mechanism by which proactive control regulates distractor interference is not yet understood, proactive control has been proposed to facilitate target processing (Egner & Hirsch, 2005; Grimshaw et al., 2017) and/or suppress distractor processing (Geng, 2014; Grimshaw et al., 2017). Both of these mechanisms have been used primarily to explain how proactive control might work in visual tasks, such as when cues indicate target location (e.g., Heinze et al., 1994) or distractor color (e.g., Arita, Carlisle, & Woodman, 2012). However, it is less clear how these explanations apply to a PWI task when a word distractor is superimposed on a target picture. For example, with respect to suppression of distractors, Geng (2014) suggested that specific distractor *features* such as location or color may be proactively suppressed.

However, suppression of word distractors most certainly differs, as words are distinguished by their semantic characteristics and not by perceptual features. One possible explanation for why cueing was effective for taboo distractors (in Experiment 1), but not for negative or neutral distractors is that cueing might help suppress words with well-defined semantic characteristics, such as taboo words because they are easily identified and categorized: Taboo words comprise a small set of words that are defined by their highly-arousing, socially-inappropriate (and oftentimes offensive) nature (Janschewitz, 2008; Jay, 2009). Evidence in support of this idea comes from research showing that taboo words produce two emotional responses, one specific to the taboo word and one more general to the taboo category (MacKay, Shafto, Taylor, Marian, Abrams, & Dyer, 2004). Cueing may reduce taboo interference by diminishing the emotional response that is common for all taboo words, i.e., the global "tabooness" property. In contrast, the emotional response to the specific taboo word remains (Röer, Körner, Buchner, & Bell, 2017), which then must be controlled reactively upon encountering the word. Nonetheless, it is clear that future research is needed to elucidate the exact mechanisms by which proactive control enhances performance when distractors are words.

To date, the majority of studies investigating the viability of the Dual Mechanisms of Control account have focused on attention tasks that employ emotionally-neutral stimuli. However, using emotional distractors has the potential to inform this theory. Braver (2012) outlined three types of variation that affects the use of proactive control: (1) situational demands such as the working memory load of a task, (2) stable individual differences such as working memory capacity, and (3) between-group variation such as age. Finding a taboo cueing effect in the present study suggest a fourth type of variation: Proactive control can be engaged to minimize interference from specific types of *stimuli*, specifically stimuli that have high potential for interference (e.g., taboo words). Furthermore, the Dual Mechanisms of Control account proposes that when proactive control cannot be effectively engaged, there is a shift to reliance on reactive control to manage interference from a distractor. This shift can explain our finding of no cueing effect for taboo trials when precued and uncued trials were mixed, as mixing trials created an unpredictability that made it more difficult to engage proactive control.

Future research should investigate whether selective engagement of proactive control occurs for any trial that is most disruptive in an experimental context. That is, whether proactive control is engaged because of the uniquely emotional nature of the taboo words or because taboo words were the most interfering in these studies remains to be determined. Although cueing of negative distractors was not found in our experiments, it is possible that interference from negative distractors may be reduced by precues in a context where those distractors are the most interfering (i.e., in the absence of taboo distractors). Another possibility to explore is the role of valence vs. arousal in engaging proactive control. In the present experiments, taboo distractors differed from negative distractors on both dimensions, specifically taboo distractors were more arousing but less negative in valence. The finding that cue was utilized for taboo but not negative distractors may indicate that proactive control is more likely to be engaged as function of arousal instead of valence, but further research is warranted.

Our findings suggest a role for proactive control in reducing interference during language processing, which has implications for theories of speech production. While the prevailing explanations for regulation of distractor interference postulate self monitors (e.g., Dhooge & Hartsuiker, 2012) or reactive control mechanisms (e.g., Roelofs, 2003) that respond to distractors after their detection, they do not currently incorporate proactive mechanisms. Although there is some evidence that self monitors can adapt based on context (e.g., the number of real-word vs.

pseudoword distractors in an experiment; Dhooge & Hartsuiker, 2012), this adaptation would be more consistent with a global proactive strategy like that applied in mostly incongruent Stroop contexts rather than item-level proactive control as was shown here. It is also unclear how precues would facilitate the process of a distractor word entering and exiting an output buffer prior to the target name entering the buffer and being prepared for articulation. Finding evidence of cueing benefits in PWI might be more easily accommodated in the WEAVER++ model, which already specifies a role for attentional control and could potentially be expanded to include both proactive and reactive mechanisms.

In conclusion, these experiments are the first to demonstrate a role for proactive control in reducing distractor interference during speech production. However, as with research using attention tasks such as Stroop, there are limits to the effectiveness with which proactive control can assist reactive control in reducing interference. Practically, our evidence suggests that we can predict and therefore reduce the interference from the vulgar friend, although we are likely to be less effective if we cannot predict when those vulgarities will emerge. Theoretically, our findings suggest the need for theories to accommodate the ways in which emotion, attention, and speech production interact with each other and to explain the mechanisms underlying these interactions.

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Author Notes

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Appendix

Target Pictures and Associated Distractors

Target Picture	**Taboo**	**Negative**	**Neutral**
acorn	dildo	devil	icebox
apple	hooker	blister	context
arrow	pussy	tumor	elbow
bird	tits	debt	phase
boat	anus	riot	jelly
boot	semen	prison	patent
camera	boner	pervert	golfer
chain	orgasm	funeral	privacy
crab	horny	gossip	fabric
crown	masturbate	hurricane	utensil
dice	twat	flood	fork
doll	breasts	rage	board
duck	bastard	hostage	poster
glove	turd	snob	foam
hammer	cunt	trash	quart
hand	piss	tomb	desk
leaf	whore	corpse	vest
mustache	bullshit	torture	salad
pie	ass	gun	ship
radio	fart	fraud	nun
rattle	dick	wasp	stool
shoe	blowjob	killer	ketchup
snail	cum	crash	farm
table	slut	crutch	swamp
telescope	penis	maggot	errand
toaster	asshole	coffin	office
umbrella	scrotum	headache	machine
violin	clit	bomb	tool
web	nipples	demon	locker
whistle	cock	lice	mop

Table 1.

Means (and Standard Deviations) of Lexical and Emotional Characteristics Matched Across Distractors

	SUBTLEX Frequency	Word Length	Phono N	Bigram Freq	Valence	Arousal	Tabooness
Taboo Distractors	22.27 (43.49)	5.23 (1.63)	12.54 (14.02)	2617.03 (1411.45)	4.44 [a] (1.54)	5.65 [a] (0.74)	5.40 (1.02)
Negative Distractors	23.60 (40.11)	5.43 (1.41)	8.73 (9.84)	2453.90 (1540.46)	2.61 (0.58)	5.18 (0.95)	1.74 [b] (0.52)
Neutral Distractors	22.32 (41.46)	5.23 (1.19)	9.37 (10.22)	2285.11 (1613.78)	5.38 (0.57)	3.37 (0.54)	0.96 [c] (0.34)

Note. Word length refers to the number of letters. PhonoN refers to phonological neighborhood. Valence and arousal means are from the Warriner et al. (2013) norms and tabooness means are from the Janschewitz (2008) norms.

[a] These means are based on 29 of the 30 taboo distractors that were included in the Warriner et al. database.

[b] This mean is based on 15 of 30 negative distractors that are found in the Janschewitz database.

[c] This mean is based on 21 of 30 neutral distractors that are found in the Janschewitz database.

Table 2

Mean Naming Times (and Standard Deviations, in ms) for Target Pictures in Experiments 1 and 2

	Experiment 1		Experiment 2	
	Uncued Target	Precued Target	Uncued Target	Precued Target
Taboo Distractor	1113 (189)	979 (192)	1067 (203)	1043 (177)
Negative Distractor	907 (139)	910 (151)	970 (150)	977 (159)
Neutral Distractor	872 (130)	869 (128)	935 (134)	921 (131)

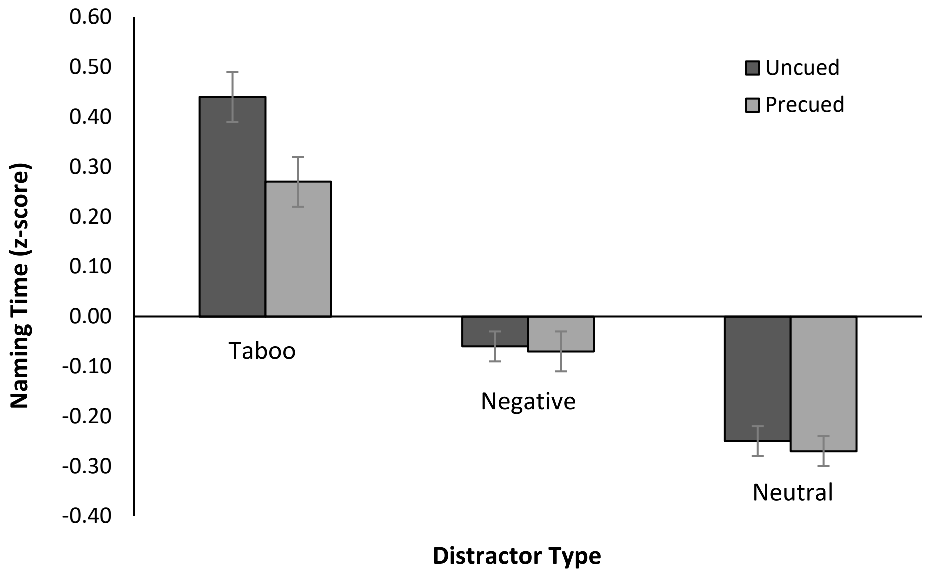

Figure 1. Mean picture naming time (z-scores) in Experiment 1, as a function of cue type (uncued, precued) and distractor type (taboo, negative, neutral). Positive values represent slowed naming times.