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When Stimulus-Driven Control Settings Compete: On the Dominance of Categories as Cues for Control

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Stimulus-driven or reactive control refers to the modulation of attention poststimulus onset via retrieval of learned control settings associated with task stimuli. The present study asked which stimulus-driven control setting "wins" the competition when more than 1 is available to guide attention. Utilizing an item-specific proportion congruence manipulation in a picture–word Stroop task, 7 experiments examined competition between item-level and category-level control settings. In Experiment 1, category-level control dominated as evidenced by transfer of control to unique 50% congruent items (exemplars) from biased (33% or 67% congruent) animal categories. In Experiment 2, the dominance persisted—transfer was observed even for inconsistent transfer items (e.g., 83% congruent bird from a 33% congruent bird category). Recategorization of the exemplars prior to the Stroop task (Experiment 3a) successfully shifted the dominance to item-level control as did changing the Stroop task goal (Experiment 4a); however, exposure to the exemplars (Experiment 3b) and individuation training prior to the Stroop task did not (Experiments 3c and 4b). These novel findings suggest category-level control dominates in guiding attention poststimulus onset, but this dominance is dependent on contextual features (i.e., mutable). We propose a salience account of dominance and discuss implications for item-based computational models.

Public Significance Statement

Attention is guided by associations formed with stimuli in our past, which is referred to as stimulus-driven control. The present study showed that when participants identified stimuli from preexisting categories, attention was predominantly guided by category-level associations. Shockingly, this tendency was apparent even when those associations were nonoptimal because a given item (exemplar) differed dramatically from the overarching category. The present study additionally demonstrated that attention was instead guided by item-level associations (a) when the category boundaries were blurred via recategorization, and (b) when participants responded to items without referring to the category name. The findings may offer insights into situations in which category-associated information (e.g., stereotypes) guides action.

Keywords: cognitive control, stimulus-attention/stimulus-control associations, item-specific proportion congruence, categories, transfer

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During the last decade or so a surge of studies demonstrating "stimulus-driven" or "reactive" control has compelled researchers to significantly expand theoretical conceptualizations of cognitive control beyond traditional accounts (e.g., Posner & Snyder, 1975; Shiffrin & Schneider, 1977). No longer is it the case that cognitive control mechanisms are thought exclusively to be slow-acting, strategic, and effortful; instead, control mechanisms also have been shown to be fast acting, implicit, and seemingly effortless. We refer to this latter class of mechanisms as stimulus-driven (Bugg, 2012) or reactive control (Braver, Gray, & Burgess, 2007) because these labels aptly capture the assumption that control mechanisms of this type are activated by the relatively automatic retrieval of learned stimulus-control associations (i.e., stimulus-attention associations) poststimulus onset (Bugg & Crump, 2012; Chiu, Jiang, & Egner, 2017; Crump & Milliken, 2009).

A major advantage of stimulus-driven control is that it enables the goal-oriented biasing of attention to be "outsourced" to the environment—that is, control can operate reactively based on an accumulation of prior experiences (i.e., instances; Logan, 1988) that are stored and rapidly retrieved when stimuli from our past are encountered.

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Accordingly, there is a significant role for learning and memory processes in this form of control (cf. Abrahamse, Braem, Notebaert, & Verguts, 2016; Egner, 2014). For instance, the episodic retrieval account posits that stimuli and their conflict histories are bound in episodic representations along with the control settings that were used to select relevant over irrelevant information when interacting with stimuli in the past (Crump & Milliken, 2009; see also the instance-based memory account of contextual control, Crump, 2016). Later encountering a stimulus from one's past elicits retrieval of the associated control settings, producing on-the-fly adjustments to attention. The overarching aim of the current study relates to a yet-to-be addressed theoretical question: Which stimulus features are encoded and bound to control settings? Only stimulus features that are correlated with conflict history become bound to the associated control settings; however, it is unknown which stimulus feature dominates, so to speak, when more than one feature is correlated with conflict history. In other words, when more than one stimulus-control association is available to guide attention (i.e., when more than one stimulus-driven control setting exists), which one wins the competition (i.e., dominates)? The evidence to date tells us that the competition likely is not resolved via an intentional selection mechanism (i.e., we do not willfully choose to activate one stimulus-driven control setting instead of another). This is because reactive adjustments occur rapidly and independent of participants' awareness of the stimulus-control associations (episodic representations) underlying such adjustments (e.g., participants cannot accurately report that a given stimulus was mostly conflicting and thus associated with a control setting that filtered irrelevant information; Crump, Gong, & Milliken, 2006; Crump, Vaquero, & Milliken, 2008; Diede & Bugg, 2017; cf. Entel, Tzelgov, & Bereby-Meyer, 2014; but see Schouppe, Ridderinkhof, Verguts, & Notebaert, 2014), hence the term "automatic control" (Jacoby, Lindsay, & Hessels, 2003). However, without clearer answers to these questions, models cannot predict which stimuli will reactively trigger control in the future and which will not. We sought to systematically investigate this theoretical issue and in so doing, inform extant accounts and models of cognitive control.

As a starting point we chose to examine competition between item-control and category-control associations. From a theoretical perspective, doing so offers broad utility in that many (if not all) stimuli we encounter can be encoded at both an exemplar (item) and category level. Furthermore, given (a) the critical role of memory processes in stimulus-driven control; (b) the well-established influence of categorical representations in the storage and retrieval of information in/from memory (e.g., Murphy, 2002; Sternberg & Ben-Zeev, 2001; Wisniewski, 2002; Yamauchi, 2005); and (c) the intimate relationship between categorization and attention (Logan, 2002; Nosofsky, 1986), it seemed a fruitful extension to examine the influence of category representations in the storage and retrieval of cognitive control settings (cf. Chua & Gauthier, 2016, for evidence of categorical representations guiding attention during visual search). We next describe the current evidence for control at the item and category levels.

Stimulus-Control Associations at the Item and Category Levels

The notion that control may operate at more than one level in tasks such as Stroop accords with extant views including the dual-mechanisms of control account (Braver et al., 2007) and the multiple levels of control framework (Bugg, 2012; Bugg, 2017; Bugg & Crump, 2012; Bugg, Jacoby, & Toth, 2008). The general assumption is that control may operate in a global fashion at the list level, which the dual-mechanisms account labels proactive, or it may operate more locally with this lower level representing reactive control. Of relevance to the present study is the reactive control mechanism that operates at the item level. Such item-level control is evidenced in item-specific proportion congruence (ISPC) paradigms. In a Stroop color-naming variant (Bugg & Hutchison, 2013, Experiments 1 and 2), one set of items (e.g., colors blue and red) is assigned to the mostly congruent (MC) condition and a separate set of items (e.g., colors green and white) is assigned to the mostly incongruent (MI) condition (see Bugg, 2015, for ISPC manipulations using flanker stimuli). MC items are presented with a congruent word on ~75% of trials and an incongruent word on ~25% of trials; the converse is true for MI items. Critically, the MC and MI items are randomly intermixed in lists that are 50% congruent such that participants cannot predict in advance which item will occur on a given trial. The key finding is that the Stroop effect is attenuated for MI items compared with MC items, a pattern known as the ISPC effect. The ISPC effect has been interpreted as representing a stimulus-driven control mechanism that operates perhaps at the finest possible grain (individual items) based on associations participants learn between item features (e.g., specific colors) and control settings (Bugg, Jacoby, & Chanani, 2011). MI items (i.e., green and white items) become associated with a control setting that quickly curtails word processing whereas MC items (i.e., blue and red items) become associated with a setting that allows for fuller processing of the word (i.e., a more relaxed control setting). In other words, participants learn control settings for different items (i.e., learn item-control associations) that reflect the history of conflict associated with each item (Chiu et al., 2017).

The item feature that is predictive of ISPC (i.e., determines whether an item is in the MC set or MI set) can be termed the "ISPC signal." The ISPC signal is central to ISPC effects because, upon its identification, it triggers retrieval of the control setting associated with the item (see Shedden, Milliken, Watter, & Monteiro, 2013, for evidence that identification occurs very rapidly poststimulus onset). The ISPC signal also plays a central theoretical role. In ISPC designs in which the ISPC signal corresponds to values of the relevant dimension (e.g., to-be-named color, Bugg & Hutchison, 2013; or to-be-named picture, Bugg et al., 2011, Experiment 2; Bugg, 2014a), item-level control is observed. However, when the ISPC signal corresponds to values of the irrelevant dimension (e.g., words), the design tends to instead produce evidence for item-specific contingency learning (i.e., simple stimulus-response learning; Schmidt & Besner, 2008; see, e.g., Atalay & Misirlisoy, 2012; Bugg et al., 2011, Experiment 3; Jacoby et al., 2003; but see Bugg & Hutchison, 2013), consistent with the dual item-specific mechanism account (Bugg, 2015; Bugg & Hutchison, 2013; Bugg et al., 2011). Converging evidence has demonstrated that the two types of designs produce dissociable mechanisms. First, they are associated with unique behavioral signatures. When the ISPC signal is based on the relevant dimension, an asymmetrical ISPC effect results with a stronger effect on incongruent trials (item-specific control); when the ISPC signal is based on the irrelevant dimension, an asymmetrical ISPC effect results with a stronger effect on congruent trials, or there is a symmetrical effect (item-specific contingency learning; Bugg et al., 2011; Chiu et al., 2017). Second, the designs are associated with unique neural signatures. Learning of stimulus-control associations (ISPC signal is based on relevant dimension) but not stimulus–response associations (ISPC signal is based on irrelevant dimension) is mediated by right caudate activity (Chiu et al., 2017). Because the present investigation is concerned with stimulus-control associations and not stimulus–response associations, the present experiments adopted only designs in which the ISPC signal corresponds to values of the relevant dimension.[1]

With one exception, in all prior reports, the values of the relevant dimension that correlated with ISPC referred to a perceptual feature. For example, in the Bugg and Hutchison (2013) study described above, the color of the item (relevant dimension) served as the ISPC signal, such that MI items (e.g., stimuli presented in green or white) produced smaller Stroop effects than MC items (e.g., stimuli presented in blue or red). Consistent with the idea that the ISPC signal was color and distinct colors became associated with different control settings, transfer was observed. When novel words (e.g., PINK, YELLOW) were presented in a final block of trials, participants responded more quickly if the word was presented in one of the MI colors compared with one of the MC colors.

The single exception stems from an ISPC paradigm in which the feature of the Stroop stimulus that was predictive of ISPC was the picture (values of the relevant dimension) in a picture–word Stroop task in which participants named the picture and ignored the superimposed word (Bugg et al., 2011, Experiment 2; see Bugg, 2014a for a replication with older adults). During the first two training blocks, pictures of animals from each of two categories (e.g., birds and cats) served as MC items and pictures of animals from each of two additional animal categories (e.g., dogs and fish) served as MI items. There were four training exemplars of each animal. The third block additionally included transfer trials, which were comprised of novel, 50% congruent exemplars (unique pictures of birds, dogs, cats, and fish not encountered during training). On the view that participants learn associations between items (each picture) and control (i.e., an item level control account), Stroop effects should have been equivalent for transfer items because the novel birds/cats were 50% congruent as were the novel fish/dogs. Countering this prediction, an ISPC effect was observed not only for the training items but also for the transfer items. That is, a smaller Stroop effect was found for novel, 50% congruent, transfer pictures that were from the same category as MI items (e.g., dogs and fish) than for novel, 50% congruent pictures from the same category as MC items (e.g., birds and cats). This is especially interesting because in contrast to the transfer trials in the study of Bugg and Hutchison (2013), which paired novel words with the exact colors (ISPC signal) that appeared on training trials, transfer trials in the study of Bugg et al. (2011) did not make direct contact with the training trials. That is, the pictures on the transfer trials did not perceptually match the pictures from the training trials. Therefore, Bugg et al. (2011) proposed that the "ISPC signal" in this case may be more categorical in nature.[2] In other words, participants may have learned category-control associations based on the stimuli presented during the training block, which were then retrieved when novel exemplars from trained categories were encountered during transfer trials.

To date, however, this is the only demonstration of transfer of the ISPC effect from one set of items (exemplars) to unique items (new exemplars) from the same category (but see Chua & Gauthier, 2016, for related evidence from a visual search task). Thus, the evidence for "category-level control" is quite preliminary. The aim of Experiment 1 was to examine whether the critical transfer effect observed by Bugg et al. (2011) would survive key changes to the procedure of that study, thereby providing further evidence for category-level control, a prerequisite for pursuing the overarching aim of the current set of experiments.

Experiment 1

To evaluate the robustness of the transfer effect observed by Bugg et al. (2011), Experiment 1 attempted to systematically replicate the effect under conditions that might limit use of category-level control. Two key changes were made to the original design. First, instead of waiting until the final block of trials to present transfer items, transfer items were randomly intermixed from the beginning of the experiment. By presenting the transfer items only during the final block in the prior study (Bugg et al., 2011, Experiment 2), likely after category-control associations were acquired for the four training exemplars, the design may have disadvantaged item-level control (i.e., responding to the transfer items based on their item-level PCs of 50%). (Hereafter, we refer to "training" items/trials/exemplars as "inducer" items/trials/exemplars so as not to give the impression that training items in the present experiments were presented separately from [i.e., before] transfer items.) Second, the number of exemplars used to represent each of the animal categories on the inducer trials was decreased from four to two. For example, whereas Bugg et al. (2011) had four different birds and four different cats on inducer trials for the MC set of items, in the current experiment there were only two birds and two cats (the same was true for the MI set of items). Thus, we used the minimum number of inducer items to form a group. Similarly, instead of using three unique exemplars for transfer items, we instead used only one. Together, this second change reduced the total number of exemplars per animal category from seven to three. Based on research in the category-learning literature (e.g., Hartley & Homa, 1981; Homa, 1978), we expected that that this change may discourage use of category-level control and therefore weaken the chances of observing transfer.

If, in contrast to these ideas, the prior findings of Bugg et al. (2011) reflected the dominance of category-level control and not design artifacts, then an ISPC effect should again be found on transfer trials in the current experiment. There should be a smaller Stroop effect for 50% congruent items (exemplars) from MI animal categories than from MC animal categories. This would pro-

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[1] To be clear, in such a design, the ISPC signal (values of the picture dimension) differentially predicts PC (whether an item is MC or MI) but it does not differentially predict responses. That is because the pictures are correlated with the correct (picture-naming) response 100% of the time, regardless of whether the item is MC or MI (for further explication, see Bugg, 2012; Bugg et al., 2011). Consequently, the ISPC effect resulting from this design cannot be explained by learning of picture-response contingencies.

[2] We do not take a stance on whether the category-level representation is prototypical or feature-based (e.g., a feature that varies across exemplars but is represented in an abstract fashion). However, we assume these are "basic" level categories (cf. Rosch, 1978).

vide additional evidence for category level control (i.e., use of category-control associations to guide performance) in the ISPC paradigm.

Method

Participants. There were 36 participants (stopping rule was $N = 36$), ranging from 18–21 years of age, from Washington University in St. Louis. Participants earned class credit for participation. All participants were native English speakers, had normal or corrected to normal vision, and provided informed consent.

The sample size was informed by our prior research with younger adults (Bugg et al., 2011, Experiment 2) that used a within-subjects design and similar procedure save for the changes noted above. In that study, there were 16 participants. The effect size for the ISPC effect (item-specific PC × Trial Type interaction) for inducer (i.e., training) trials was partial eta-squared (η_p^2) = .50 and for transfer trials was $\eta_p^2 = .41$. Assuming an alpha level of .05, a comparably large effect, and a modest correlation ($r = .5$) between the repeated measures (e.g., which is very conservative given our prior data), G Power estimated power to be .95 with a sample size of four to six (Faul, Erdfelder, Lang, & Buchner, 2007). Because we assumed that the effect sizes might decrease in this and subsequent experiments given changes to the design, and because it is good practice to use larger sample sizes, we elected to test no fewer than 30 subjects in each experiment (the stopping rule is stated in the Participants section of each experiment). To foreshadow, the above assumption was confirmed in Experiment 1 where the effect size for the smaller of the two interactions was $\eta_p^2 = .12$; still, assuming all the above but using this as the effect size estimate, power is .95 with 18 subjects.

Design and materials. A completely within-subjects 2 (Item-Specific PC: MC vs. MI) × 2 (Item Type: Inducer vs. Transfer) × 2 (Trial Type: Congruent vs. Incongruent) design was used. The stimuli used in this study were a subset of a larger set of stimuli from Bugg et al. (2011). There were 12 black-and-white line drawings of animals (three birds, three cats, three dogs, and three fish; see Bugg et al., 2011, for a detailed description of the stimuli) on which an animal word (BIRD, CAT, DOG, FISH) was superimposed. On congruent trials the to-be-named picture of the animal matched the word (e.g., cat picture with CAT superimposed) whereas on incongruent trials the two dimensions conflicted (e.g., cat picture with BIRD).

As in Bugg et al. (2011), the picture (values of the relevant dimension) served as the ISPC signal. As shown in Figure 1, the pictures from the four animal categories were divided into two sets with each set comprising two animal categories. For each animal category within a set, two of the pictures were designated inducer items and one of the pictures was designated a transfer item. In the MC set (e.g., bird and cat pictures), inducer items were 75% congruent (PC-75) whereas in the MI set (e.g., dog and fish pictures), inducer items were 25% congruent (PC-25).[3,4] Transfer items in both PC sets were 50% congruent (PC-50). The assignment of pictures to the role of inducer versus transfer items was counterbalanced across participants. Combining inducer and transfer items, the PC of the MC set (pictures) was 67%, and the PC of the MI set was 33%.

Following Bugg et al. (2011, Experiment 2), the overlapping sets design was used such that incongruent trials included the animal words from the same and alternative PC set. For example, for a picture of a cat, all possible incongruent trials appeared during the task (i.e., cat with word DOG, FISH, or BIRD superimposed). Per block and collapsing across all incongruent trials, a picture was paired with each of the other animal words with equal frequency. Each animal picture was presented 12 times within a block. Thus, per block and for each PC-75 item, there were nine congruent and three incongruent trials. For each PC-25 item, there were three congruent and nine incongruent trials. For PC-50 items, there were six congruent and six incongruent trials. Table 1 provides the frequencies of the picture–word pairings collapsed across all blocks of the experiment. Combining items from both PC sets yielded a block (list-wide) PC of 50%.

Procedure. Participants provided informed consent. Then, following Bugg et al. (2011), they were instructed to name aloud the animal depicted by the picture as quickly as possible while maintaining a high level of accuracy. They were instructed to respond with the general category label (“bird,” “cat,” “dog,” or “fish”) rather than more specific labels (e.g., “robin”). On each trial the stimulus was presented via E-Prime in the center of the screen until a response was detected by the voice-key. The experimenter coded the participant’s response via keyboard, and the next stimulus appeared 1,000 ms later. Trials on which the voice-key picked up extraneous noise or undecipherable speech were coded as “scratch” trials and excluded from analyses. Reaction time (ms) and accuracy were recorded.

Participants had a short practice block with 12 trials. The PCs of the animals in the practice block mimicked those of the experimental block. Following confirmation that participants understood the task, the experimental blocks were initiated. There were three experimental blocks and brief rest breaks were provided between blocks. Each block was comprised of 144 trials (one third of each cell in Table 1). Inducer and transfer trials were randomly intermixed within each block from the start of the experiment (i.e., as opposed to presenting transfer trials only after several blocks of inducer trials as in Bugg et al., 2011).

Results

Following previous studies that used the picture–word Stroop task (e.g., Bugg & Chanani, 2011; Bugg et al., 2011), trials with reaction times (RTs) less than 200 ms or greater than 3,000 ms were excluded. This excluded <1% of the trials across partici-

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[3] The examples provided parenthetically are from one counterbalanced version of the task. In another version, bird and cat pictures were MI and dog and fish pictures were MC. We did not use all possible combinations of animals (e.g., birds and dogs, cats and dogs, etc.), only those mentioned here.

[4] In this and all subsequent experiments (see also Bugg et al., 2011), the irrelevant dimension (values of the word) was slightly predictive of PC. For training items, words in the MC set were 56% congruent and words in the MI set were 38% congruent. Collapsing training and transfer items, words were 55% congruent and 43% congruent, respectively. It has been shown that it is inconsequential whether the irrelevant dimension (words) is slightly predictive of ISPC (Bugg et al., 2011) or not at all predictive of ISPC (i.e., 50% congruent; Chiu et al., 2017). The same behavioral pattern indicative of item-level *control* (asymmetrical ISPC effect primarily affecting incongruent trials) is found in both cases, and analysis of errors demonstrates that item-specific contingency (word-response) learning is not responsible for this pattern (Bugg, 2014a; Bugg & Hutchison, 2013).

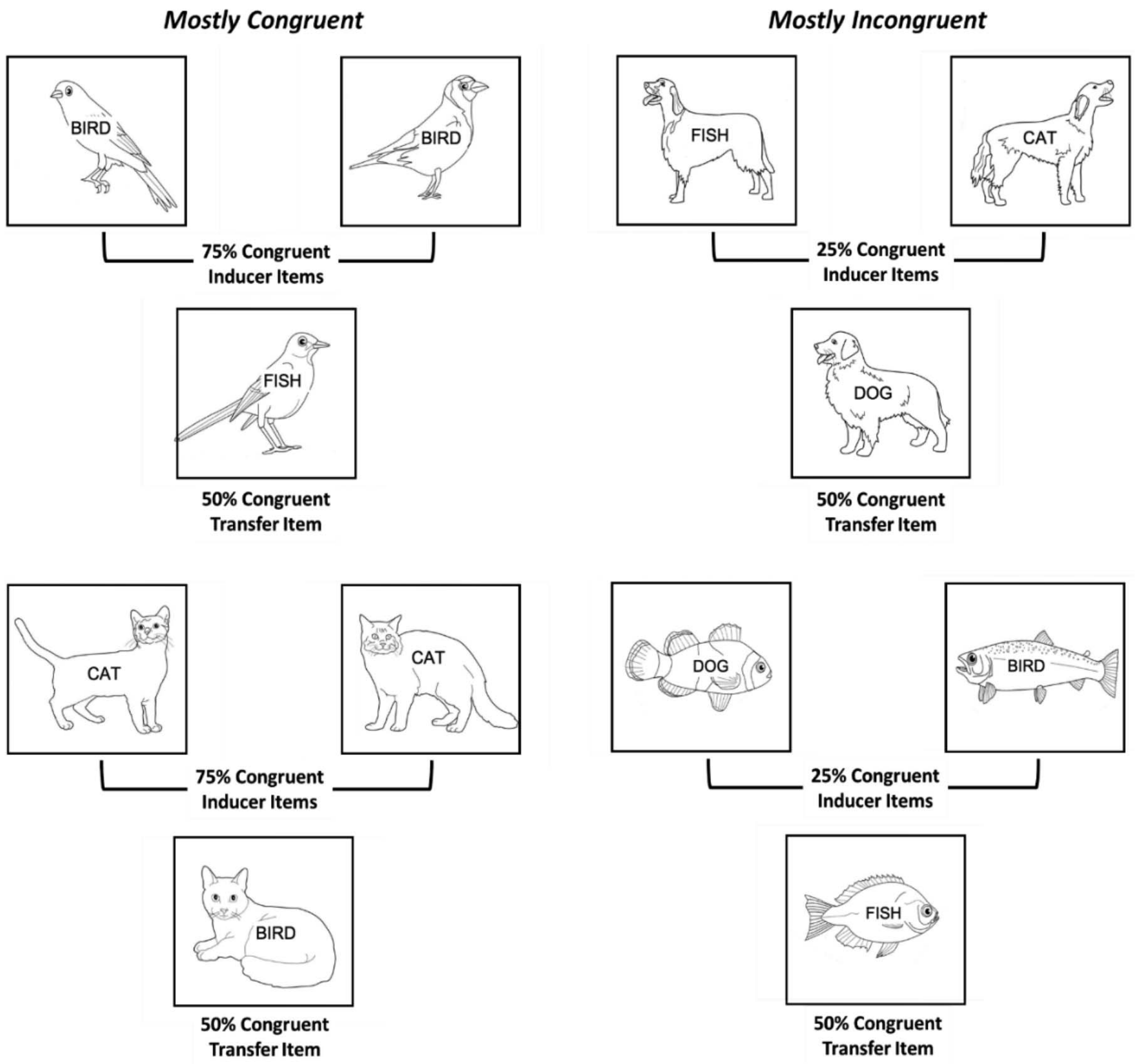

Figure 1. Sample picture–word Stroop stimuli for Experiment 1. Depicted is one of the counterbalances in which the inducer items for birds and cats were mostly congruent and dogs and fish were mostly incongruent. Transfer items for each animal were unbiased (50% congruent).

pants. In addition, for the analysis of reaction time (RT), error trials were excluded. Here and in all subsequent experiments, the alpha level for all analyses was set to .05 and effect sizes are reported as partial eta-squared (η_p^2). The theoretically meaningful effects are captured by the item-specific PC × Trial Type interactions. These interactions index the ISPC effect for inducer items, and generalization of the ISPC effect to transfer items (i.e., category-based ISPC effect). When these interactions do not reach significance, we report the relative evidence of the model that includes the interaction to the model that excludes the interaction using a Bayesian approach via the statistical software JASP (JASP, 2014; https://jasp-stats.org/) Version 0.8.1.2. Specifically, we take the ratio of the Bayes factor (BF) of the full model with the interaction to the BF of the main effects only model. We report this ratio as BF_{10}. For reference, a BF_{10} equal to 1 indicates that the models are equivocal. $BF_{10} = .50$ indicates that the main effects only model predicted the data two times better than the full model. $BF_{10} = 2$ indicates that the full model predicted the data two times better than the main effects only model.

Analyses were performed separately for inducer and transfer items (Bugg & Chanani, 2011; Bugg et al., 2011).[5] For each item type, a 2 × 2 within-subject ANOVA was conducted with item-

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[5] This analytic approach follows the convention in the literature across many labs when examining the effects of a PC bias induced by training items on unbiased (50% congruent) transfer items (e.g., Bugg & Hutchison, 2013; Cañadas et al., 2013; Crump & Milliken, 2009; Gonthier et al., 2016; Hutchison, 2011). The two item types constitute different frequencies (i.e., there are necessarily more inducer than transfer items, otherwise one cannot have biased categories [contexts, lists, etc.] and unbiased transfer items), and thus it is difficult to interpret any item type differences (e.g., differences may be due to event learning processes; see e.g., Crump & Milliken, 2009).

Table 1
Frequencies of Picture–Word Pairings Collapsed Across Blocks in Experiment 1

		Picture			
Item type	Word	Bird	Cat	Dog	Fish
Inducer	BIRD	54	6	18	18
	CAT	6	54	18	18
	DOG	6	6	18	18
	FISH	6	6	18	18
Transfer	BIRD	18	6	6	6
	CAT	6	18	6	6
	DOG	6	6	18	6
	FISH	6	6	6	18

Note. Underlined numbers represent the frequencies of congruent trials. For inducer items, the frequencies were derived by collapsing across two different pictures of a corresponding animal type (i.e., two different bird pictures were each presented with the word BIRD nine times *per* block). Because there was only one transfer item per set, frequencies of those items were derived from a single picture. The frequencies in this table represent one counterbalance in which birds and cats are mostly congruent and dogs and fish are mostly incongruent.

specific PC and trial type as factors. *Note that for the analysis of transfer items, which were PC-50 regardless of set, the factor item-specific PC refers to the PC of the other items in the set (category).* The mean RTs and standard errors are shown in Table 2.

Reaction time.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 35) = 198.22$, $p < .001$, $\eta_p^2 = .85$, such that incongruent trials ($M = 691$ ms, $SE = 14$ ms) were responded to slower than congruent trials ($M = 598$ ms, $SE = 12$ ms). This was qualified by an item-specific PC × Trial Type interaction (i.e., ISPC effect), $F(1, 35) = 17.28$, $p < .001$, $\eta_p^2 = .33$. The Stroop effect was significantly attenuated for the MI items compared with the MC items (see Figure 2).

Transfer items (PC-50). There was a main effect of trial type, $F(1, 35) = 153.65$, $p < .001$, $\eta_p^2 = .81$, such that incongruent trials ($M = 694$ ms, $SE = 14$ ms) were responded to slower than congruent trials ($M = 601$ ms, $SE = 12$ ms). Most importantly, like the inducer items, this effect was qualified by an item-specific PC × Trial Type interaction (i.e., ISPC effect)[6] despite the items themselves being PC-50, $F(1, 35) = 4.61$, $p = .039$, $\eta_p^2 = .12$. The Stroop effect was significantly attenuated for PC-50 items that were exemplars from the MI set (category) compared with PC-50 items that were exemplars from the MC set (see Figure 2).

Error rate.

Inducer items (PC-75/25). The 2 × 2 ANOVA revealed a significant main effect of trial type, $F(1, 35) = 31.72$, $p < .001$, $\eta_p^2 = .48$, such that incongruent trials ($M = .037$, $SE = .006$) had a larger error rate than congruent trials ($M = .004$, $SE = .001$). There was a marginal effect of PC, $F(1, 35) = 3.64$, $p = .065$, $\eta_p^2 = .09$, such that MC items ($M = .025$, $SE = .005$) had a higher error rate than MI items ($M = .017$, $SE = .003$). In addition, the item-specific PC × Trial Type interaction approached significance, $F(1, 35) = 3.45$, $p = .072$, $\eta_p^2 = .09$, $\mathrm{BF}_{10} = .80$, such that the Stroop effect in error rate was larger for MC items than for MI items (see Table 2).

Transfer items (PC-50). For transfer items, there was only a main effect of trial type, $F(1, 35) = 32.26$, $p < .001$, $\eta_p^2 = .48$, such that incongruent trials ($M = .039$ $SE = .006$) had a larger error rate than congruent trials ($M = .009$, $SE = .002$). There was not a significant item-specific PC × Trial Type interaction, $F(1, 35) = 1.37$, $p = .250$, $\eta_p^2 = .04$, $\mathrm{BF}_{10} = .41$.

Discussion

In Experiment 1, as in Bugg et al. (2011, Experiment 2), transfer was observed such that the asymmetrical ISPC pattern was found not just for biased, inducer items but additionally for 50% congruent transfer items. The Stroop effect was smaller for PC-50 exemplars from trained MI categories than trained MC categories. Extending Bugg et al. (2011, this pattern was observed despite two design changes we thought might attenuate the influence of category-level control. One change was to shrink the number of exemplars in the inducer and transfer sets. The second change was to embed transfer trials into the experiment from the beginning rather than waiting until a final block of trials. Neither change prevented participants from adopting and utilizing category-level control in the ISPC paradigm.

These findings further demonstrate the existence of category-level control in the picture–word Stroop task. They also provide additional evidence that category-level control may dominate in this ISPC paradigm (Bugg et al., 2011; see also Bugg, 2014a). In other words, when stimuli are encountered that afford the learning and use of item-control and category-control associations, it appears that participants are more inclined to rely on the category-control associations. This may not seem surprising when one considers the known utility of category-level representations in memory (e.g., Murphy, 2002; Sternberg & Ben-Zeev, 2001; Wisniewski, 2002; Yamauchi, 2005)—it may be more efficient to store and retrieve control settings bound to categories than to engage these processes for *each* item with which an individual has had prior experience. Given how rapidly control settings must be retrieved to reactively resolve conflict, efficiency may be especially important.

However, a circumstance in which category-level control is disadvantageous is when exemplars (e.g., individuals) have histories of conflict that differ from the overall category to which the exemplars belong. In this case, reliance on category-level instead of item-level associations to guide control may lead to adoption of a control setting that is suboptimal for a given item, potentially leading to an exacerbated Stroop effect (e.g., when encountering a mostly incongruent transfer item from a mostly congruent category) or an unnecessary heightening of control (e.g., when encountering a mostly congruent transfer item from a mostly incongruent category). The question Experiment 2 addresses is whether category-level control continues to dominate when it is not merely a viable alternative to item-level control (as in Experiment 1 and Bugg et al., 2011, Experiment 2) but in fact conflicts with item-level control (i.e., triggers retrieval of an opposing control setting).

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[6] We elected to continue to refer to the item-specific PC × Trial Type interaction on transfer trials as an ISPC effect for consistency with our prior work (Bugg et al., 2011); we recognize, however, that it might be more precise to label it a category-based ISPC effect.

Table 2
Mean Reaction Times (ms), Error Rates, and Stroop Effects for Experiment 1

	MC			MI		
Item type	Congruent	Incongruent	Stroop	Congruent	Incongruent	Stroop
Reaction time						
Inducer	601 (12)	709 (15)	108	596 (12)	673 (13)	77
Transfer	608 (11)	712 (16)	104	594 (12)	677 (12)	83
Error rate						
Inducer	.005 (.001)	.045 (.009)	.040	.004 (.002)	.029 (.005)	.025
Transfer	.010 (.003)	.045 (.008)	.035	.007 (.003)	.033 (.006)	.026

Note. The standard errors for reaction time and error rates are given within the parentheses. Inducer items were PC-75 and PC-25, respectively, in the mostly congruent (MC) and mostly incongruent (MI) conditions. Transfer items were PC-50 in the MC and in the MI condition.

Experiment 2

In Experiment 2 we examined whether transfer items that conflicted with the inducer items from the MC and MI categories show an ISPC pattern that is consistent with the overall proportion congruence of the category (implying use of category-level control) or exhibit an ISPC effect that is unique to the bias of the transfer item (implying item-level control). To examine this question, we replaced the PC-50 items from Experiment 1 with MC (PC-83) and MI (PC-17) transfer items. That is, for each animal category there were now four pictures. As in Experiment 1, two of the pictures served as inducer items and were either PC-75 or PC-25 depending on whether they were in the MC or MI set, respectively. Most critically, a third picture in each set served as an *inconsistent transfer item* and had a PC that conflicted with the PC of the inducer items in the set. In the MC set, this item was PC-17 and in the MI set this item was PC-83. A fourth picture in each set served as a *consistent transfer item* and had a PC that was consistent with but more extreme than the PC of the inducer items in the set. In the MC set, this item was PC-83 and in the MI set this item was PC-17. Inclusion of the fourth picture enabled us to maintain the overall PCs of Experiment 1 when all stimuli were combined (i.e., overall PC of the MC set was 67% and that of the MI set was 33%).

As in Experiment 1, the inducer items were ambiguous with respect to evaluating whether category or item-level control guided performance. Because the consistent transfer items were biased to be (more extremely) MC or MI at the item level and category level, they were similarly ambiguous. Thus, although an ISPC effect was expected for the inducer items and consistent transfer items, it was not theoretically discriminating. The critical predictions concerned the inconsistent transfer items. If category-level associations again prevail in guiding control, then an ISPC effect should be observed

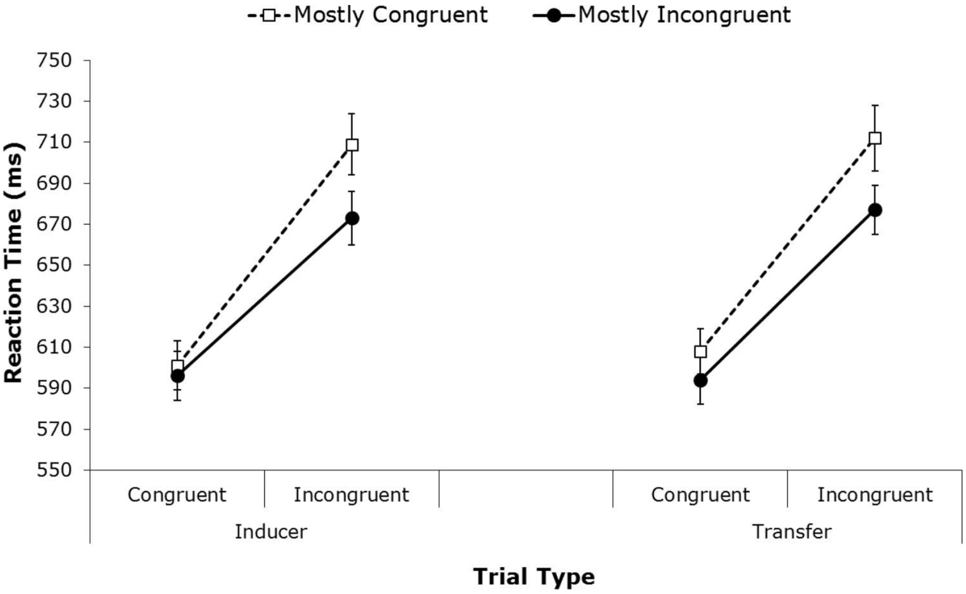

Figure 2. Reaction times on congruent and incongruent trials for inducer and transfer items in Experiment 1. For inducer items, mostly congruent (MC) and mostly incongruent (MI) refer to PC-75 and PC-25, respectively. For transfer items, MC and MI refer to the PC of the category to which the transfer items belong (PC-67 or PC-33, respectively). Transfer items were 50% congruent at the item level in the MC and MI conditions. Error bars represent standard error of the mean.

for the inconsistent transfer items such that a *smaller* Stroop effect is found for the PC-83 item (from the MI category) than the PC-17 item (from the MC category). In contrast, if item-level representations prevail, the pattern of Stroop effects should correspond to the PC of the item such that a *larger* Stroop effect is observed for the PC-83 item than the PC-17 item.

Method

Participants. There were 48 participants (stopping rule was $N = 48$), ranging from 18–22 years of age from Washington University in St. Louis. Participants earned class credit or $10 for participating. All participants were native English speakers, had normal or corrected to normal vision, and provided informed consent.

Design and materials. The design and materials were similar to Experiment 1 with the key difference being that we removed the PC-50 transfer item in each set and replaced it with two transfer items—one that had a consistent PC and one that had an inconsistent PC, relative to the inducer items in the same set (category). Thus, for inducer items a completely within-subjects 2 (Item-Specific PC: MC vs. MI) × 2 (Trial Type: Congruent vs. Incongruent) design was used. For transfer items, a within-subjects 2 (Item-Specific PC) × 2 (Item Type: Consistent Transfer vs. Inconsistent Transfer) × 2 (Trial Type) design was used.

As in Experiment 1, there were two animal categories per PC set. However, each category had four pictures—two pictures that served as inducer items, one consistent transfer item, and one inconsistent transfer item. As in Experiment 1 inducer items were either PC-75 or PC-25 for MC and MI sets, respectively. Consistent transfer items in MC sets were PC-83, and in MI sets they were PC-17. Inconsistent transfer items in MC sets were PC-17, and in MI sets they were PC-83. Combining inducer and transfer items, the overall proportion congruence of the MC set and MI set remained at 67% and 33%, respectively, as in Experiment 1. The four pictures within each animal category were divided into two pairs. One pair was assigned to be the inducer items while the other pair was assigned to be the transfer items. The assignment of inducer and transfer item pairs was counterbalanced across participants. Additionally, the assignment of consistent and inconsistent transfer items was counterbalanced across participants within the transfer pair.

Table 3 provides the frequencies for each picture–word pairing collapsed across all blocks. Each inducer item was presented 12 times per block, as was the case in Experiment 1. To maintain the overall PC of the MC and MI sets, each PC-83 and PC-17 item was presented six times per block. Because this yields a relatively small number of observations per cell for transfer items, we doubled the number of blocks from the first experiment. In addition, because of the smaller number of observations for consistent and inconsistent transfer items per block, for these items, pictures did not appear equally often with each word on incongruent trials in a given block; however, across the six blocks, each picture was paired equally often with each incongruent word.

Procedure. The procedure was the same as Experiment 1 except that participants completed six blocks of 144 trials following practice.

Table 3
Frequencies of Picture–Word Pairings Collapsed Across All Blocks in Experiment 2

		Picture			
Item type	Word	Bird	Cat	Dog	Fish
Inducer	BIRD	108	12	36	36
	CAT	12	108	36	36
	DOG	12	12	36	36
	FISH	12	12	36	36
Consistent transfer	BIRD	30	2	10	10
	CAT	2	30	10	10
	DOG	2	2	6	10
	FISH	2	2	10	6
Inconsistent transfer	BIRD	6	10	2	2
	CAT	10	6	2	2
	DOG	10	10	30	2
	FISH	10	10	2	30

Note. Underlined numbers represent the frequencies of congruent trials. The frequencies for all item types were calculated after collapsing across all six blocks of the experiment. In addition, for inducer items, the frequencies were derived by collapsing across two different pictures of a corresponding animal type (i.e., two different pictures of birds were each presented with the word BIRD nine times per block). Because there was only one consistent and inconsistent transfer item per set, frequencies of those items were derived from a single picture. The frequencies in this table represent one counterbalance in which birds and cats are mostly congruent and dogs and fish are mostly incongruent.

Results

Using the same RT outlier exclusion criteria as in Experiment 1, <1% of trials were excluded. In addition, for the analysis of RT, error trials were again excluded. As in Experiment 1, separate ANOVAs were performed to examine the inducer and transfer trials. First, a 2 × 2 within-subjects ANOVA was conducted with item-specific PC and trial type as factors to examine the ISPC effect for inducer items. Second, a 2 × 2 × 2 within-subjects ANOVA was conducted to examine the ISPC effect for transfer items. This ANOVA additionally included item type (consistent vs. inconsistent transfer items). As in Experiment 1, *for the analysis of transfer items, the factor item-specific PC refers to the PC of the inducer items in the set (category) not the PC of the transfer items*. The mean RTs and standard errors are shown in Table 4.

Reaction time.

Inducer items (PC-75/25). The 2 × 2 ANOVA revealed a main effect of trial type, $F(1, 47) = 459.37$, $p < .001$, $\eta_p^2 = .91$, such that incongruent trials ($M = 703$ ms, $SE = 9$ ms) were responded to slower than congruent trials ($M = 612$ ms, $SE = 8$ ms). There was also a main effect of item-specific PC, $F(1, 47) = 9.38$, $p = .004$, $\eta_p^2 = .17$, such that MC items ($M = 662$ ms, $SE = 9$ ms) were responded to slower than MI items ($M = 652$ ms, $SE = 9$ ms). Importantly, these effects were qualified by an item-specific PC × Trial Type interaction (i.e., ISPC effect), $F(1, 47) = 16.94$, $p < .001$, $\eta_p^2 = .27$. The Stroop effect was significantly attenuated for MI items compared with MC items (see Figure 3).

Transfer items (PC-83/17). A 2 × 2 × 2 ANOVA revealed a main effect of trial type, $F(1, 47) = 259.27$, $p < .001$, $\eta_p^2 = .85$, such that incongruent trials ($M = 703$ ms, $SE = 9$ ms) were responded to slower than congruent trials ($M = 616$ ms, $SE = 9$

Table 4
Mean Reaction Times (ms), Error Rates, and Stroop Effects for Experiment 2

Item type	MC			MI		
	Congruent	Incongruent	Stroop	Congruent	Incongruent	Stroop
Reaction time						
Inducer	612 (8)	712 (10)	100	611 (8)	693 (9)	82
Consistent transfer	616 (9)	712 (11)	96	617 (10)	694 (9)	77
Inconsistent transfer	621 (9)	714 (10)	93	613 (9)	691 (11)	78
Error rate						
Inducer	.004 (.002)	.040 (.006)	.036	.006 (.001)	.036 (.004)	.030
Consistent transfer	.007 (.002)	.061 (.014)	.054	.007 (.003)	.035 (.005)	.028
Inconsistent transfer	.003 (.002)	.052 (.009)	.049	.006 (.002)	.042 (.011)	.036

Note. The standard errors for reaction time and error rates are given within the parentheses. Inducer items were PC-75 and PC-25, respectively, in the mostly congruent (MC) and mostly incongruent (MI) conditions. Transfer items were PC-50 in the MC and in the MI condition. Consistent transfer items were PC-83 and PC-17, respectively, in the MC and MI conditions. Inconsistent transfer items were PC-17 and PC-83, respectively, in the MC and MI conditions.

ms). There was also a main effect of item-specific PC, $F(1, 47) = 9.53$, $p = .003$, $\eta_p^2 = .17$, such that MC items ($M = 666$ ms, $SE = 9$ ms) were responded to slower than MI items ($M = 654$ ms, $SE = 9$ ms). Importantly, this was qualified by an item-specific PC × Trial Type interaction (i.e., ISPC effect), $F(1, 47) = 8.78$, $p = .005$, $\eta_p^2 = .16$. The Stroop effect was significantly attenuated for transfer items in the MI set compared with the MC set. Most importantly, the three-way interaction failed to reach significance, $F < 1$, $p = .633$, $\eta_p^2 = .01$, $BF_{10} = .22$. We take this as evidence indicating that the ISPC effect did not differ between consistent and inconsistent transfer items despite their dramatically differing item-specific PCs (see Figure 3).

Error rate.

Inducer items (PC-75/25). The 2 × 2 ANOVA revealed only a significant main effect of trial type, $F(1, 47) = 50.14$, $p < .001$, $\eta_p^2 = .52$, such that incongruent trials ($M = .038$, $SE = .005$) had a larger error rate than congruent trials ($M = .005$, $SE = .001$). There was not a significant item-specific PC × Trial Type interaction, $F(1, 47) = 1.43$, $p = .238$, $\eta_p^2 = .03$, $BF_{10} = .28$.

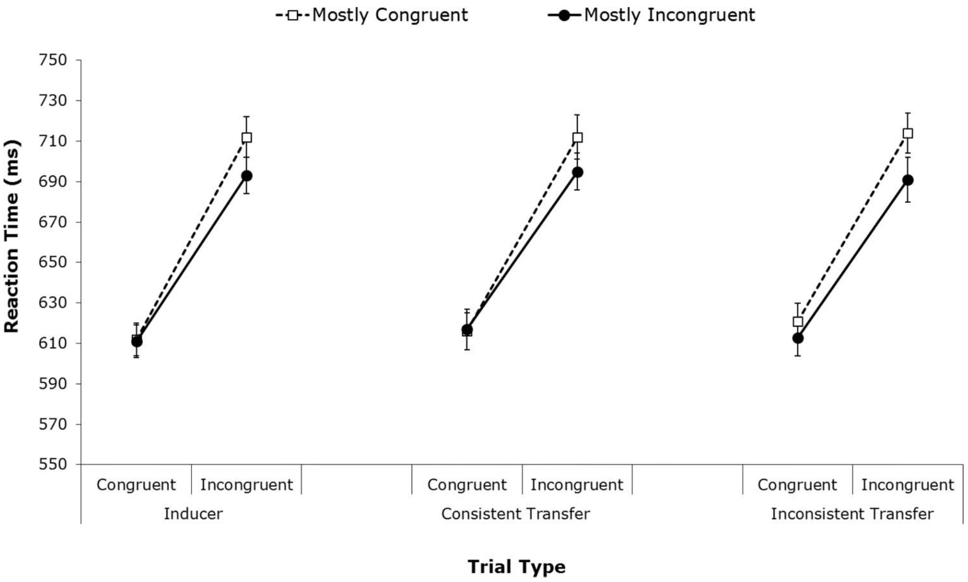

Figure 3. Reaction times on congruent and incongruent trials for inducer, consistent transfer, and inconsistent transfer items in Experiment 3. For inducer items, mostly congruent (MC) and mostly incongruent refer to PC-75 and PC-25, respectively. For transfer items, mostly congruent and mostly incongruent refer to the PC of the category to which the transfer items belong (PC-67 or PC-33, respectively). Note that consistent transfer items had item-specific PCs similar to inducer items in the same category (e.g., MC inducer item = 75%, MC transfer item = 83%) whereas inconsistent transfer items had dissimilar item-specific PCs (e.g., MC inducer item = 75%, MC transfer item = 17%). Error bars represent standard error of the mean.

Transfer items (PC-83/17). The $2 \times 2 \times 2$ ANOVA revealed only a main effect of trial type, $F(1, 47) = 41.80$, $p < .001$, $\eta_p^2 = .47$, such that incongruent trials ($M = .048$, $SE = .007$) had a larger error rate than congruent trials ($M = .006$, $SE = .001$). The item-specific PC × Trial Type interaction approached significance, $F(1, 47) = 3.04$, $p = .088$, $\eta_p^2 = .06$. Most importantly, the three-way interaction failed to reach significance, $F < 1$, $p = .400$, $\eta_p^2 = .02$, $BF_{10} = .29$.

Discussion

As expected an ISPC effect was found for the inducer items and the consistent transfer items such that the Stroop effect was smaller for both types of items in the MI condition compared with the MC condition. The key finding was that the pattern observed on inconsistent transfer items was the same as that observed for consistent transfer items. Demonstrating that category-level and not item-level control was dominant, a *smaller* Stroop effect was found for MC items from a MI category than for MI items from a MC category. This suggests that category-level control is not discriminating. In other words, when a stimulus comprises the categorical signal that triggers category-level control, it adjusts attention as it would for any item in the category. The specific history of the item is not considered; rather, the control setting is overgeneralized such that category-inconsistent items are treated stereotypically. This means that control was inappropriately relaxed for PC-17 (MI) transfer items because they were from a MC category and control was unnecessarily heightened for PC-83 (MC) items because they were from a MI category.

These findings converge with and significantly extend those of Experiment 1 and Bugg et al. (2011). The fact that participants continued to utilize category-control associations (i.e., category level control) in the face of item-control associations that strongly conflicted with the PC of the category to which the items belonged suggests a highly pervasive tendency for participants to adopt category-level control. This suggests the dominant ISPC signal may be the category represented by the picture and not the item (exemplar) itself. Perhaps the most critical question that arises from these findings is: Can one bias adoption of item-level control under task conditions where category-level control routinely dominates, or is its dominance immutable? The remaining experiments addressed this question with an eye toward gathering evidence to inform a preliminary theoretical account of factors that determine which signal dominates in guiding attention poststimulus onset.

Experiment 3a

In Experiment 3a, we returned to the design of Experiment 1 in which category-level control dominated and addressed a novel aim: Can the dominance of category-level control be disrupted in the present task context (i.e., using same stimuli, task goal, etc.)? We aimed to bias learning in favor of item-control associations by engaging participants in a "recategorization" phase prior to the Stroop task. Borrowed from the literature on social categorization (e.g., Gaertner, Mann, Murrell, & Dovidio, 1989), recategorization is assumed to "degrade the salience" of the existing categorical boundaries (p. 239). Participants were introduced to the names of three fictional "pet owners" (Catherine, Pat, and Dani) and were told that each owner had four pets—one bird, one cat, one dog, and one fish. Participants were asked to study each animal and their associated owner, and tested on the owner-pet associations. This task involves recategorization because the three animals within each preexisting category (e.g., dogs) were redistributed across the three levels of the category (pet owner) introduced during the recategorization phase, thereby blurring the boundaries of the preexisting category. Following the recategorization phase, participants performed the Stroop task, which was identical to Experiment 1.

Assuming the dominance of category-level control is mutable, the key prediction was as follows: If recategorization successfully biases participants away from using the animal category to guide control, then the ISPC effect should be found for the inducer items (because inducer items benefit from learning either item-control or category-control associations) but not the transfer items (because transfer items are 50% congruent at the item level). An ISPC effect on the transfer items should occur only if category-level control continues to dominate.

Method

Participants. There were 48 participants (stopping rule was $N = 48$), ranging from 18–22 years of age, from Washington University in St. Louis. Participants were either given class credit or $10 for participating. All participants were native English speakers, had normal or corrected to normal vision, and provided informed consent.

Design and materials. The design and materials were identical to Experiment 1.

Procedure. The procedure was the same as Experiment 1 barring the addition of the recategorization phase prior to the Stroop task. In this phase, participants were asked to study self-paced slides presenting the owner names and the pictures of the animals associated with those owners. For all participants, there were three owners, and each owner had four pets (one randomly chosen bird, cat, dog, and fish). First, the three owner–pet slides were presented (Catherine, Pat, and Dani). The slides displayed the owner's name with pictures of all four associated pets. Next participants were shown a slide that had the names of all owners with the pictures of their corresponding pets beneath their names so that they could directly compare exemplars. Participants were free to study each of the slides for as long as they wanted. After all owner–pet slides were presented, participants had a choice to go back and review the slides (as many times as they wished) or move on to the test phase. In the test phase, participants were presented with pictures of the 12 animals (pets) one at a time in a random order. They were asked to press one of three keys on the keyboard to indicate which owner each pet belonged to. To proceed to the next stage of the experiment, participants either had to get eight or more correct responses or they had to perform the test phase three times (with intervening opportunities for restudy). All but one participant, whose best score was 50% correct, reached criterion within three attempts.[7]

Participants were then introduced to and completed the Stroop task following the procedure outlined in Experiment 1 (i.e., no mention of the previous phase [recategorization] was made). At the end of the Stroop task, participants took a surprise memory test (four-alternative forced choice) to see if they remembered the

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[7] Excluding this participant does not meaningfully change any results or conclusions in this experiment.

owner-pet associations. In this test, we also included novel animal pictures that were never presented during the experiment. Just like the first test phase, pictures of each pet/animal were presented one at a time in a random order. For each animal picture, they had to choose between one of the three owners, or they could indicate that the picture was of a new animal, all via the keyboard.

Results

Using the same RT outlier exclusion criteria as the previous experiments, we excluded <1% of trials. In addition, for the analysis of RT, error trials were excluded. As in Experiment 1, to examine whether an ISPC effect was evidenced for inducer items, and separately for transfer items, we ran two 2 × 2 ANOVAs with item-specific PC and trial type as factors. *Again, for transfer items, item-specific PC refers to the PC of the other items in the set (category) because transfer items were 50% congruent.* The mean RTs and standard errors are shown in Table 5.

Reaction time.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 47) = 369.72$, $p < .001$, $\eta_p^2 = .88$, such that incongruent trials (M = 703 ms, SE = 12 ms) were responded to slower than congruent trials (M = 606 ms, SE = 10 ms). There was also a main effect of item-specific PC, $F(1, 47) = 15.32$, $p < .001$, $\eta_p^2 = .25$, such that MC items (M = 663 ms, SE = 11 ms) were responded to slower than MI items (M = 646 ms, SE = 10 ms). These effects were qualified by an item-specific PC × Trial Type interaction (ISPC effect), $F(1, 47) = 6.70$, $p = .013$, $\eta_p^2 = .13$. The Stroop effect was significantly attenuated for the MI items compared with the MC items (see Figure 4).

Transfer items (PC-50). There was a main effect of trial type, $F(1, 47) = 270.77$, $p < .001$, $\eta_p^2 = .85$, such that incongruent trials (M = 701 ms, SE = 12 ms) were responded to slower than congruent trials (M = 607 ms, SE = 10 ms). There was also a main effect of item-specific PC, $F(1, 47) = 4.22$, $p = .045$, $\eta_p^2 = .08$, such that transfer items from the MC set (M = 658 ms, SE = 11 ms) were responded to slower than transfer items from the MI set (M = 649 ms, SE = 12 ms). Most critically, there was not an item-specific PC × Trial Type interaction for the transfer items, $F(1, 47) = 1.86$, $p = .179$, $\eta_p^2 = .04$, $\text{BF}_{10} = .25$. We take this as evidence indicating that the Stroop effect did not differ between transfer items that belonged to the MC and MI categories.

Error rate.

Inducer items (PC-75/25). The 2 × 2 ANOVA revealed a significant main effect of trial type, $F(1, 47) = 61.36$, $p < .001$, $\eta_p^2 = .57$, such that incongruent trials (M = .038, SE = .004) had a larger error rate than congruent trials (M = .007, SE = .001). There was also a significant main effect of item-specific PC, $F(1, 47) = 5.79$, $p = .020$, $\eta_p^2 = .11$, such that MC items (M = .028, SE = .002) had a higher error rate than MI items (M = .018, SE = .002). These main effects were qualified by an item-specific PC × Trial Type interaction (i.e., ISPC effect), $F(1, 47) = 10.11$, $p = .003$, $\eta_p^2 = .18$, such that there was a larger increase in error rate from congruent to incongruent trials for MC compared with MI items, consistent with the RT analysis (see Table 5).

Transfer items (PC-50). There was a main effect of trial type, $F(1, 47) = 47.62$, $p < .001$, $\eta_p^2 = .50$, such that incongruent trials (M = .030 SE = .003) had a larger error rate than congruent trials (M = .006, SE = .001). In addition, there was also a significant main effect of item-specific PC, $F(1, 47) = 6.25$, $p = .016$, $\eta_p^2 = .12$, such that transfer items from the MC set (M = .022, SE = .003) had a higher error rate than transfer items from the MI set (M = .014, SE = .002). However, as with RT, there was not a significant item-specific PC × Trial Type interaction, $F(1, 47) = .02$, $p = .901$, $\eta_p^2 < .001$, $\text{BF}_{10} = .21$. Similar to the RT analysis, we take this as evidence indicating that the Stroop effect did not differ between transfer items that belonged to the MC and MI categories.

Performance on memory test. Average performance across all pre-Stroop tests was good (M = .82, SE = .02). Participants performed equally well on the post-Stroop test (M = .84, SE = .02) as the last pre-Stroop test (M = .85, SE = .02), $t(47) = .45$, $p = .656$, and well above chance (.33).

Examination of owner-based PC effects. As noted in the Method section, a single bird, cat, dog, and fish were randomly linked to each owner, and these pet–owner associations were the same for all participants. Because the PC of the animal exemplars in the Stroop task varied across participants (e.g., across counterbalanced versions "Bird 1" could be MC, MI, or PC-50), the PC of the owners (i.e., PC for *all* animals associated with a given owner) also varied. Across the different counterbalanced versions, each owner was associated with one of five PC values (37.5%, 43.75%, 50%, 56.75%, 62.5%). To examine whether the success of recategorization in biasing participants against using (animal-based) category-level control was attributable to participants learning and responding based on owner PC instead of category PC, we used HLM to analyze the effect of trial type, owner PC, and their interaction. HLM was appropriate given the unbalanced design (i.e., none of the counterbalanced versions contained all

Table 5
Mean Reaction Times (ms), Error Rates, and Stroop Effects for Experiment 3a

	MC			MI		
Item type	Congruent	Incongruent	Stroop	Congruent	Incongruent	Stroop
Reaction time						
Inducer	611 (10)	715 (13)	104	602 (11)	690 (11)	88
Transfer	609 (10)	708 (13)	99	605 (11)	694 (13)	89
Error rate						
Inducer	.007 (.001)	.048 (.007)	.041	.007 (.002)	.028 (.003)	.021
Transfer	.010 (.002)	.034 (.006)	.024	.001 (.001)	.026 (.005)	.025

Note. The standard errors for reaction time and error rates are given within the parentheses. Inducer items were PC-75 and PC-25, respectively, in the mostly congruent (MC) and mostly incongruent (MI) conditions. Transfer items were PC-50 in the MC and in the MI condition.

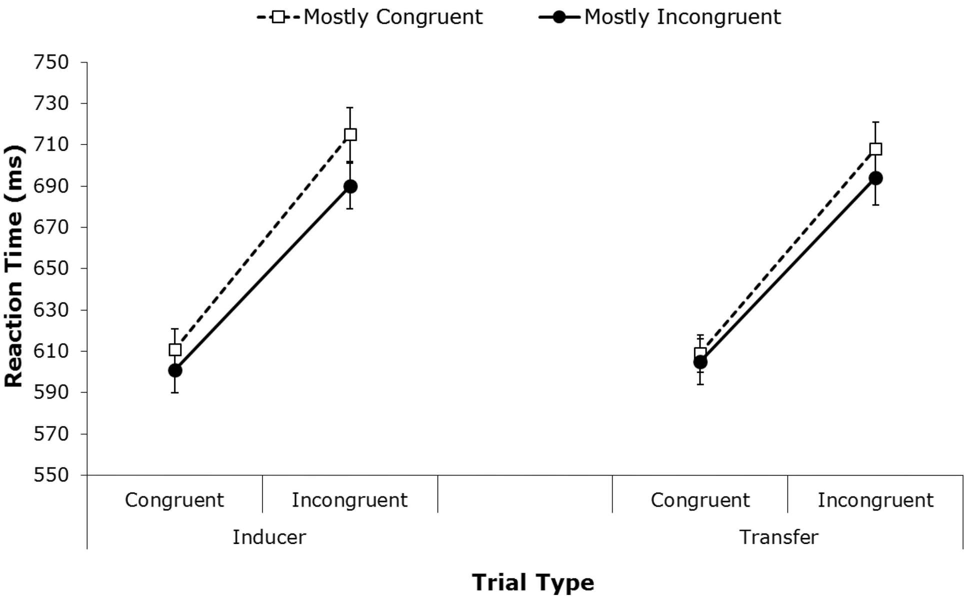

Figure 4. Reaction times on congruent and incongruent trials for inducer and transfer items in Experiment 3a. For inducer items, mostly congruent (MC) and mostly incongruent (MI) refer to PC-75 and PC-25, respectively. For transfer items, MC and MI refer to the PC of the category to which the transfer items belong (PC-67 or PC-33, respectively). Transfer items were 50% congruent at the item level in the MC and MI conditions. Error bars represent standard error of the mean.

five levels of owner PC). The full results are reported in the online supplementary materials. To summarize, there was not a main effect of owner PC or an owner PC × Trial Type interaction in any of the models (for either RT or accuracy, in either inducer or transfer trials). This suggests that the Stroop effect did not vary as a function of owner PC; that is, participants did not learn control settings corresponding to the PC of the owners and respond on this basis. Using HLM, we additionally examined whether owner PC might have changed the nature of the ISPC effect reported in the main analyses for inducer and/or transfer items. It did not. There was not a three-way interaction between item-specific PC (animal-based), owner PC, and trial type in any of the models (for either RT or accuracy, in either inducer or transfer trials).

Discussion

Unlike in the previous experiments, transfer was not observed in Experiment 3a. That is, PC-50 animals from trained MC animal categories were not attended to differently from PC-50 animals from trained MI animal categories as evidenced by the equivalent Stroop effects for these two sets of transfer items. This suggests that category-level control did not dominate, and the recategorization phase was successful in promoting item-level control (i.e., learning/use of item-control associations) in the subsequent Stroop task. While we cannot rule out that category-level control contributed to the ISPC effect that was observed for inducer items, the lack of significant transfer in the present experiment is consistent with the interpretation that item-level control dominated.

The findings of Experiment 3a provide preliminary evidence that reliance on category-level control to guide attention is mutable in the present task context (i.e., present stimuli, goal, etc.). In the next two experiments we aimed to pinpoint whether there was a specific component of the recategorization phase that was critical for its success in disrupting use of category-level control. One possibility is that the critical factor is merely preexposing participants to the stimuli (i.e., increasing familiarity of each exemplar) prior to the Stroop task. A second possibility is that the critical factor is the individuation process—participants had to *actively* differentiate among the exemplars (e.g., the three dogs) to learn which dog corresponded to which owner. A third possibility is that the presence of a competing category (e.g., pet owner) is the critical factor. The results of the analyses of owner PC suggest participants did *not* learn or respond (modulate attention) based on the PC of the owner, nor did the competing category simply create noise (i.e., in which case both item-level and category-level control should have been compromised). Rather, the presence of a competing category may be important for degrading the salience of the animal category (cf. Gaertner et al., 1989), which may disrupt use of (animal-based) category-level control. Experiments 3b and 3c, respectively, addressed these possibilities.

Experiment 3b

To examine whether increased familiarity with the exemplars alone is sufficient to bias participants to adopt item-level instead of category-level control, thereby precluding transfer, participants were exposed to the exemplars prior to the Stroop phase but were not encouraged to individuate exemplars or engage in recategorization. Exposure time was yoked to the time participants spent studying during the recategorization phase in Experiment 3a. If the dominance of item-level control in Experiment 3a was due to exposure, then transfer should again not be observed. If, in contrast, processes unique to recategorization (either the act of individuating to learn the owner-pet associations or the presence of a competing category) promoted use of item-level control, then category-level control should again dominate, and transfer should be observed.

Method

Participants. There were 48 participants (stopping rule was $N = 48$), ranging from 18–23 years of age, from Washington University in St. Louis. Participants were either given class credit or $10 for participating. All participants were native English speakers, had normal or corrected to normal vision, and provided informed consent.

Design and materials. The design and materials were identical to Experiment 3a.

Procedure. The procedure was identical to Experiment 3a save for the following exceptions. The recategorization phase was replaced with an exposure phase in which participants were presented with each exemplar and asked to view it prior to the Stroop task. To equate exposure time as closely as possible with Experiment 3a, we derived the average amount of time participants studied the exemplars in Experiment 3a and presented the exemplars in Experiment 3b for the same amount of time. Participants first viewed each exemplar for 8.5 s. Then they viewed all 12 exemplars on one screen for 40.7 s. Importantly, participants were given no instructions to study the exemplars (either for purposes of individuation or recategorization), nor was any reference to pet owners made. As in Experiment 3a, participants subsequently completed the Stroop task and were then given a surprise memory test for the exemplars. However, unlike Experiment 3a, this was simply an old-new recognition task that included 12 old and 12 new exemplars.

Results

Reaction time. The same analyses were performed as in Experiment 3a. Trimming eliminated <1% of the data. Means and standard errors for RT and error rate are displayed in Table 6.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 47) = 312.39$, $p < .001$, $\eta_p^2 = .87$, such that incongruent trials ($M = 718$ ms, $SE = 11$ ms) were responded to slower than congruent trials ($M = 622$ ms, $SE = 9$ ms). There was also a main effect of item-specific PC, $F(1, 47) = 12.27$, $p = .001$, $\eta_p^2 = .20$, such that MC items ($M = 677$ ms, $SE = 10$ ms) were responded to slower than MI items ($M = 662$ ms, $SE = 10$ ms). These effects were qualified by an item-specific PC × Trial Type interaction (i.e., ISPC effect), $F(1, 47) = 9.00$, $p = .004$, $\eta_p^2 = .16$. The Stroop effect was larger for MC compared with MI items (see Figure 5).

Transfer items (PC-50). There was a main effect of trial type, $F(1, 47) = 485.52$, $p < .001$, $\eta_p^2 = .91$, such that incongruent trials ($M = 719$, $SE = 10$) were responded to slower than congruent trials ($M = 626$, $SE = 11$). There was also a main effect of item-specific PC, $F(1, 47) = 19.65$, $p < .001$, $\eta_p^2 = .30$, such that PC-50 items from the MC set ($M = 681$ ms, $SE = 10$ ms) were responded to slower than PC-50 items from the MI set ($M = 662$ ms, $SE = 10$ ms). Most importantly, there was an item-specific PC × Trial Type interaction (i.e., ISPC effect), $F(1, 47) = 5.56$, $p = .02$, $\eta_p^2 = .11$, indicative of transfer. The Stroop effect was larger for PC-50 items from a trained MC category compared with PC-50 items from a trained MI category (see Figure 5).

Error rate.

Inducer items (PC-75/25). There was a significant main effect of trial type, $F(1, 47) = 52.16$, $p < .001$, $\eta_p^2 = .53$, such that incongruent trials ($M = .038$, $SE = .005$) had a larger error rate than congruent trials ($M = .006$, $SE = .001$). There was also a significant main effect of item-specific PC, $F(1, 47) = 6.16$, $p = .017$, $\eta_p^2 = .17$, such that MC items ($M = .027$, $SE = .004$) had a higher error rate than MI items ($M = .017$, $SE = .002$). These main effects were qualified by an item-specific PC × Trial Type interaction, $F(1, 47) = 4.12$, $p = .048$, $\eta_p^2 = .08$, such that there was a larger increase in error rate from congruent to incongruent trials for MC compared with MI items, consistent with the RT analysis.

Transfer items (PC-50). There was only a main effect of trial type, $F(1, 47) = 54.86$, $p < .001$, $\eta_p^2 = .54$, such that incongruent trials ($M = .041$, $SE = .005$) had a larger error rate than congruent trials ($M = .003$, $SE = .001$). There was not a significant item-specific PC × Trial Type interaction, $F(1, 47) = 1.17$, $p = .285$, $\eta_p^2 = .02$, $\mathrm{BF}_{10} = .32$.

Performance on memory test. We examined participants' ability to distinguish old animals from new animals post-Stroop task. Overall, participants performed well above chance ($M = .92$, $SE = .01$), $t(47) = 42.31$, $p < .001$.

Discussion

The primary finding was that simply exposing participants to the animal exemplars for an equivalent amount of time without asking them to engage in recategorization did not bias reliance on item-level control. Instead, consistent with the use of category-level

Table 6

Mean Reaction Times (ms), Error Rates, and Stroop Effects for Experiment 3b

	MC			MI		
Item type	Congruent	Incongruent	Stroop	Congruent	Incongruent	Stroop
Reaction time						
Inducer	625 (10)	731 (12)	106	619 (10)	706 (11)	87
Transfer	631 (11)	732 (11)	101	621 (11)	705 (11)	84
Error rate						
Inducer	.007 (.002)	.048 (.008)	.041	.005 (.002)	.029 (.003)	.024
Transfer	.004 (.002)	.046 (.007)	.042	.002 (.001)	.036 (.006)	.034

Note. The standard errors for reaction time and error rates are given within the parentheses. Inducer items were PC-75 and PC-25, respectively, in the mostly congruent (MC) and mostly incongruent (MI) conditions. Transfer items were PC-50 in the MC and in the MI condition.

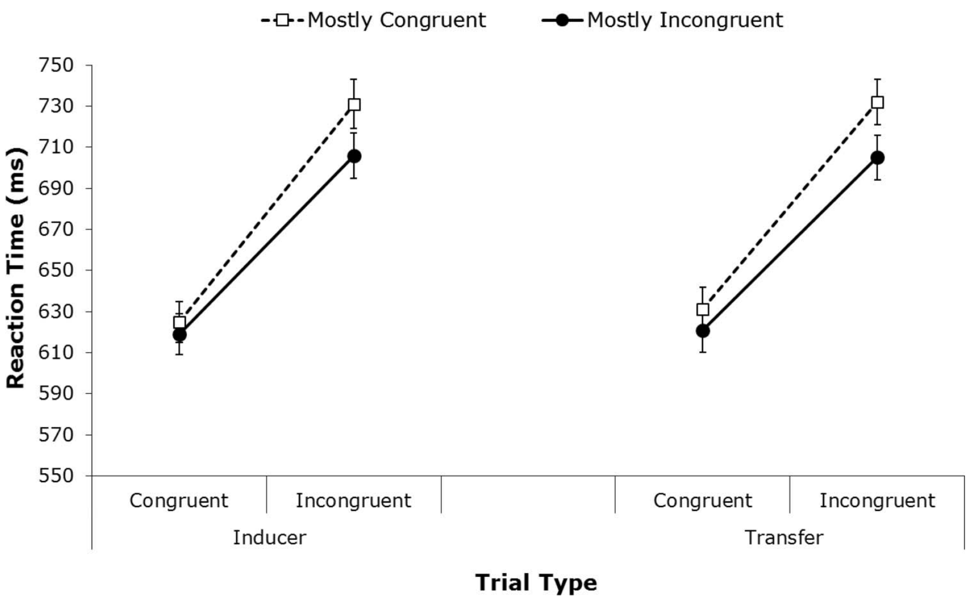

Figure 5. Reaction times on congruent and incongruent trials for inducer and transfer items in Experiment 3b. For inducer items, mostly congruent (MC) and mostly incongruent (MI) refer to PC-75 and PC-25, respectively. For transfer items, MC and MI refer to the PC of the category to which the transfer items belong (PC-67 or PC-33, respectively). Transfer items were 50% congruent at the item level in the MC and MI conditions. Error bars represent standard error of the mean.

control, a transfer effect was found. The Stroop effect was smaller for PC-50 exemplars from the trained MI animal categories than PC-50 exemplars from trained MC animal categories. This suggests that familiarity with the exemplars is insufficient to shift the dominance from category- to item-level control.

Experiment 3c

The purpose of Experiment 3c was to examine the generality of the effect observed in Experiment 3a, namely whether the ability to bias participants away from use of category-level control was specific to the recategorization process employed in Experiment 3a. For example, it may be that the presence of the competing category (pet owner) was critical for disrupting use of (animal-based) category-level control. Alternatively, the critical factor that disrupted category-level control may have been the act of differentiating among (i.e., individuating) the exemplars within each animal category (which was necessary to learn which dog, bird, etc. was linked to each owner), in which case “individuation training” without recategorization should also be successful. Indeed, there is evidence from different paradigms showing that encouraging participants to focus on unique features of a target is associated with a shift away from category-based processing (e.g., Hugenberg, Miller, & Claypool, 2007; Lebrecht, Pierce, Tarr, & Tanaka, 2009). Most relevant to the present study, in the context-specific PC literature (i.e., where PC is associated with different contexts such as locations), individuation training deterred participants from using category-level information to recruit control settings (Cañadas, Rodríguez-Bailón, Milliken, & Lupiáñez, 2013). A flanker task was used in which a picture of a face was briefly presented prior to the onset of a flanker stimulus. The face could be a female or male, and each gender was associated with a distinct context-specific PC (either MC or MI). For example, if female was associated with MC, then following a female face there was a 75% likelihood of encountering a congruent flanker stimulus. It was found that asking participants to individuate faces by focusing on identity-based features of each face blocked the use of gender category to guide control as indicated by a lack of transfer of the context-specific PC effect.

The predictions were as follows. If individuation training on its own successfully biases adoption of item-level control, then an ISPC effect should be found for inducer but not transfer items. However, if processes unique to recategorization promoted use of item-level control in Experiment 3a, then category-level control should again dominate, and transfer should be observed.

Method

Participants. There were 48 participants (stopping rule was $N = 48$), ranging from 18–22 years of age, from Washington University in St. Louis. Participants were either given class credit or $10 for participating. All participants were native English speakers, had normal or corrected to normal vision, and provided informed consent.

Design and materials. The design and materials were identical to Experiment 3a.

Procedure. The procedure was identical to Experiment 3a with the following exceptions. Participants were asked to associate each exemplar with a pet name. This required participants to actively individuate the animals; however, in contrast to Experiment 3a, this process did not involve recategorization. Participants studied self-paced slides that presented pet names above their respective exemplars. All participants studied the same 12 animal–pet name associations (i.e., three birds, three dogs, etc.) presented in a random order. Pet names were chosen with the following constraints: names were one to two syllables in length, no name started with a letter or phoneme that corresponded to the category to which the animal belonged, and names that were associated with animals in popular American media were excluded (e.g., Tweety, Garfield, Goofy, Nemo). At the end of the random sequence, a slide was presented that displayed all the exemplars with the associated pet names; this allowed participants to directly compare exemplars, as in Experiment 3a. Participants then had a choice to go back and review the slides (as many times as they wished) or move on to the test phase. In the test phase, participants were presented with pictures of the 12 exemplars one at a time in a random order. They were asked to verbally respond with the name of the pet. To proceed to the next stage of the experiment (i.e., Stroop task), participants had to get nine or more correct responses. If they failed to do so, they were given an opportunity to study the slides again and retake the test until they "passed."

Results

The same analyses were performed as in Experiment 3a. Trimming eliminated $<1\%$ of the data. Means and standard errors for RT and error rate are displayed in Table 7.

Reaction time.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 47) = 346.80$, $p < .001$, $\eta_p^2 = .88$, such that incongruent trials ($M = 721$ ms, $SE = 15$ ms) were responded to slower than congruent trials ($M = 628$ ms, $SE = 13$ ms). There was also a main effect of item-specific PC, $F(1, 47) = 9.07$, $p = .004$, $\eta_p^2 = .16$, such that MC items ($M = 682$ ms, $SE = 14$ ms) were responded to slower than MI items ($M = 667$ ms, $SE = 14$ ms). These effects were qualified by an item-specific PC × Trial Type interaction (ISPC effect), $F(1, 47) = 9.63$, $p = .003$, $\eta_p^2 = .17$. The Stroop effect was significantly attenuated for the MI items compared with the MC items (see Figure 6).

Transfer items (PC-50). There was a main effect of trial type, $F(1, 47) = 331.54$, $p < .001$, $\eta_p^2 = .88$, such that incongruent trials ($M = 723$ ms, $SE = 16$ ms) were responded to slower than congruent trials ($M = 633$ ms, $SE = 13$ ms). There was also a trending main effect of item-specific PC, $F(1, 47) = 3.98$, $p = .052$, $\eta_p^2 = .08$, such that transfer items from the MC set ($M = 683$ ms, $SE = 14$ ms) were responded to slower than transfer items from the MI set ($M = 672$ ms, $SE = 14$ ms). Most critically, there was an item-specific PC × Trial Type interaction for the transfer items, $F(1, 47) = 6.50$, $p = .014$, $\eta_p^2 = .12$. The Stroop effect was significantly attenuated for the MI items compared with the MC items (see Figure 6).

Error rate.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 47) = 43.57$, $p < .001$, $\eta_p^2 = .48$, such that incongruent trials ($M = .030$, $SE = .003$) had a larger error rate than congruent trials ($M = .008$, $SE = .001$). There was no main effect of item-specific PC, $F(1, 47) = 3.42$, $p = .071$, $\eta_p^2 = .06$. There was a trending item-specific PC × Trial Type interaction, $F(1, 47) = 3.79$, $p = .058$, $\eta_p^2 = .08$, $\text{BF}_{10} = .76$.

Transfer items (PC-50). There was a main effect of trial type, $F(1, 47) = 46.36$, $p < .001$, $\eta_p^2 = .50$, such that incongruent trials ($M = .038$, $SE = .004$) had a larger error rate than congruent trials ($M = .009$, $SE = .002$). There was no main effect of item-specific PC, $F < 1$, $p = .559$, $\eta_p^2 = .01$. In addition, there was no item-specific PC × Trial Type interaction, $F < 1$, $p = .539$, $\eta_p^2 = .01$, $\text{BF}_{10} = .25$. We take this as evidence indicating that the Stroop effect in error rate did not differ between transfer items that belonged to the MC and MI categories.

Performance on memory test. Across all pre-Stroop tests, performance was good ($M = .79$, $SE = .02$). Participants performed just as well on the post-Stroop test ($M = .87$, $SE = .02$) as on the last pre-Stroop test ($M = .90$, $SE = .01$), $t(47) = 1.73$, $p = .089$, and in all cases well above chance (.08).

Discussion

The key finding of Experiment 3c was that category-level control dominated, as evidenced by an ISPC effect for both inducer and transfer items. Having participants individuate exemplars by learning arbitrary pet names for each animal, a form of individuation training, did not successfully bias participants against using category-level control. This contrasts with findings from the context-specific PC literature (Cañadas et al., 2013) where a form of individuation training biased participants from using a gender category to guide control of flanker task interference. This also contrasts with the findings from Experiment 3a showing that engaging participants in a recategorization phase prior to the Stroop task biased participants against using category-level control. The implication is that the presence of a competing category and not individuation of exemplars per se was the critical factor that disrupted category-level control in Experiment 3a.

Table 7
Mean Reaction Times (ms), Error Rates, and Stroop Effects for Experiment 3c

	MC			MI		
Item type	Congruent	Incongruent	Stroop	Congruent	Incongruent	Stroop
Reaction time						
Inducer	630 (12)	734 (16)	104	626 (14)	708 (15)	82
Transfer	633 (12)	733 (17)	100	632 (14)	713 (15)	81
Error rate						
Inducer	.008 (.002)	.035 (.005)	.027	.007 (.002)	.025 (.003)	.018
Transfer	.009 (.002)	.035 (.006)	.026	.010 (.003)	.041 (.005)	.031

Note. The standard errors for reaction time and error rates are given within the parentheses. Inducer items were PC-75 and PC-25, respectively, in the mostly congruent (MC) and mostly incongruent (MI) conditions. Transfer items were PC-50 in the MC and in the MI condition.

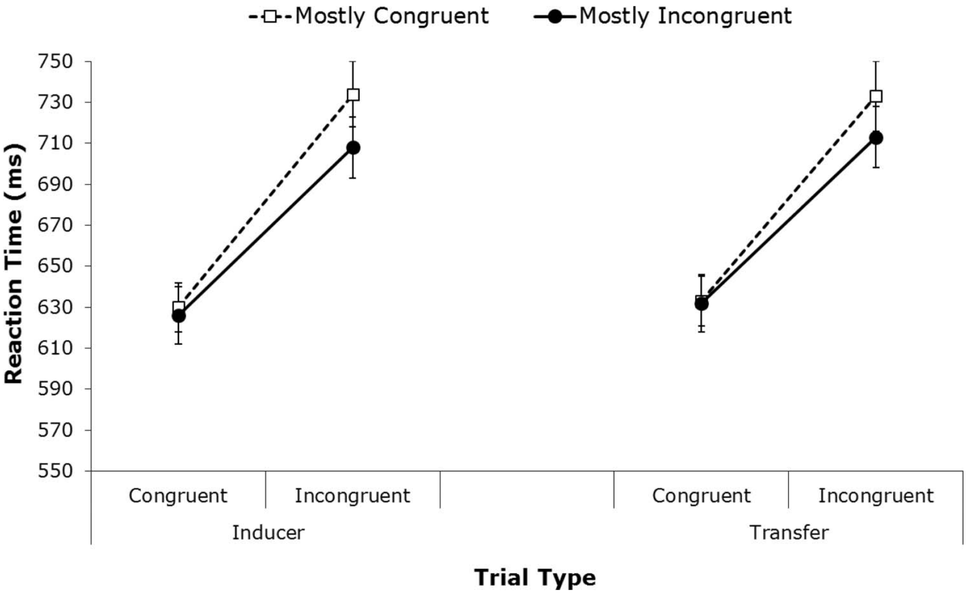

Figure 6. Reaction times on congruent and incongruent trials for inducer and transfer items in Experiment 3c. For inducer items, mostly congruent (MC) and mostly incongruent (MI) refer to PC-75 and PC-25, respectively. For transfer items, MC and MI refer to the PC of the category to which the transfer items belong (PC-67 or PC-33, respectively). Transfer items were 50% congruent at the item level in the MC and MI conditions. Error bars represent standard error of the mean.

Considering the collective pattern of results, it is also notable that a transfer effect was found in Experiments 3b and 3c but not Experiment 3a because the ISPC effect for inducer items was reduced in all three experiments relative to Experiment 1 ($\eta_p^2 s$ = .16, .16, and .13, respectively, relative to .33 in Experiment 1). The reduction may reflect that any exposure to the stimuli prior to the Stroop task generates a familiarity signal when stimuli are reencountered during the Stroop task, and this signal may interfere somewhat with the stimulus-driven retrieval of control settings. Regardless of the cause, this pattern suggests that the presence (or absence) of transfer is not driven merely by the magnitude of the ISPC effect for inducer items. Rather, selective strategies appear to disrupt transfer (i.e., use of category-level control) whereas others do not. These findings raise the interesting question of why some but not other attempts to bias adoption of item-level control are successful in the present task context. We reserve discussion of this question and the broader implications of these findings for the General Discussion.

Experiment 4a

The primary theoretical aim of Experiment 4a was to begin to address the question of *why* participants tend to learn and utilize category-control associations instead of item-control associations. One possibility is that category-level control is inherently dominant; in contrast, we posit that there may be critical contextual factors that lead to the dominance of category-level control in the present task. These include the task stimuli (i.e., animals representing preexisting categories with superimposed words corresponding to the animal *category*) and/or the task goal (i.e., name the animal in the picture by using the *category-level* name such as “bird” or “dog”). Indeed, all five preceding experiments shared these task features and only one (Experiment 3a) found evidence that item-level control can dominate under these conditions. However, none of the preceding experiments tested the role of either factor in promoting use of category-level control. In Experiment 4a we filled this gap by changing the task goal. We asked participants to learn the names of each of the exemplars (e.g., “oriole,” “lab”) *and* use these exemplar-level names when naming the pictures during the Stroop task.[8] However, the picture–word stimuli were still comprised of an animal picture paired with a congruent or incongruent word and these words still corresponded to the general category (e.g., bird, dog). This has two notable consequences. The first is that it allows us to isolate the role of task goal. If item-level control now dominates (as indicated by an ISPC effect selectively for training trials), this would provide support for the view that the task goal and not the task stimuli dictates dominance of item versus category-level signals. If category-level control continues to dominate (as evidenced by transfer), then this would leave open an interpretation that attributes dominance to the task stimuli.

The second consequence is that the correct (exemplar-level) response (e.g., “oriole,” “lab”) never overlaps with the superimposed word (e.g., BIRD, CAT, FISH, or DOG). While it should still take longer to respond to incongruent stimuli (e.g., a picture of an oriole with the word DOG superimposed) than congruent stimuli (e.g., a picture of an oriole with the word BIRD superimposed), we expected the magnitude of the difference (i.e., Stroop effect) to be reduced in the present experiment. The reason why is because irrelevant words that are not from the eligible response set produce

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[8] Technically, assuming the basic categories are bird, dog, etc., what we refer to as exemplar-level names are known as “subordinate categories” in the category learning literature (Rosch, 1978).

less interference than words that are used as responses (e.g., Lamers, Roelofs, & Rabeling-Keus, 2010; see Risko, Schmidt, & Besner, 2006, for a similar pattern with color associates as in the semantic Stroop effect). The irrelevant words BIRD, DOG, and so forth are not part of the eligible response set (e.g., "oriole," "lab") in the present experiment. As such, the locus of the Stroop effect may occur at a higher level (i.e., competition between the category depicted by the word and the to-be-named exemplar) and/or involve response competition only indirectly (e.g., when an oriole is encountered with the word DOG superimposed, DOG may indirectly activate responses "lab," "pitbull," etc. which may interfere with responding; cf. Roelofs, 2003).

To foreshadow the results for inducer items, although the Stroop effect was reduced, there was an ISPC effect such that the Stroop effect was smaller for MI items than MC items and the ISPC pattern (i.e., asymmetrical with a more pronounced effect on incongruent trials) mirrored that observed in the preceding experiments. Thus, Experiment 4a afforded the opportunity to address the key question which was whether the act of responding with the exemplar-level names biased participants against learning and using category-control associations, as evaluated by performance on the transfer trials. If item-level control dominates, then there should not be an ISPC effect for transfer trials. This would conceptually replicate the results of Experiment 3a by demonstrating category-level control is mutable.

Method

Participants. There were 30 participants (stopping rule was $N = 30$), ranging from 18–21 years of age, from Washington University in St. Louis. Participants were either given class credit or $10 for participating. All participants were native English speakers, had normal or corrected to normal vision, and provided informed consent.

Design and materials. The design was identical to Experiment 1. However, as shown in Figure 7, we changed the materials somewhat to select pictures with exemplar-level names that did not have an initial letter or phoneme that overlapped with their category name (e.g., Dalmatian was not allowed in the dog category), and to ensure that no two animals within a category shared the same initial letter or phoneme (e.g., for cats, between Siamese and Shorthair, only Siamese was used). In addition, although voice onset time was used as the measure of RT as in the prior experiments, we still took care to choose animals whose names did not exceed three syllables. When the presentation frequency of the various bird exemplars is summed across blocks, the frequencies are identical to Experiment 1. The same was true for the other animal categories (see Table 8).

Procedure. The procedure was identical to Experiment 1 with two exceptions. One exception was that participants first learned the names of each of the exemplars during a study phase. Participants viewed each exemplar with the name printed above the exemplar. They were given unlimited time to study the pairings. Then they were tested on the pairings. An exemplar was shown, and they said the name of the exemplar aloud. The experimenter pressed a key corresponding to the exemplar and then the next exemplar was shown. Participants had to get 100% correct before proceeding to the Stroop task. The second exception was that during the Stroop task, participants responded with the exemplar-level name (e.g., "cuckoo") and not the category name (e.g., "bird").

Results

The same analyses were performed as in Experiment 1 (and 3a, 3b, and 3c). Trimming eliminated <1% of the data. Means and standard errors for RT and error rate are displayed in Table 9.

Reaction time.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 29) = 15.40$, $p < .001$, $\eta_p^2 = .34$, such that incongruent trials ($M = 902$ ms, $SE = 30$ ms) were responded to slower than congruent trials ($M = 874$ ms, $SE = 27$ ms). This was qualified by an item-specific PC × Trial Type interaction (i.e., ISPC effect), $F(1, 29) = 10.38$, $p = .003$, $\eta_p^2 = .26$. The Stroop effect was significantly attenuated for the MI items compared with the MC items (see Figure 8).

Transfer items (PC-50). There was a main effect of trial type, $F(1, 29) = 5.70$, $p = .024$, $\eta_p^2 = .81$, such that incongruent trials ($M = 894$ ms, $SE = 26$ ms) were responded to slower than congruent trials ($M = 877$ ms, $SE = 24$ ms). Importantly, the item-specific PC × Trial Type interaction was not significant, $F(1, 29) = 1.40$, $p = .247$, $\eta_p^2 = .04$, $BF_{10} = .37$. We take this as evidence indicating that there was no ISPC effect for transfer items (see Figure 8).

Error rate.

Inducer items (PC-75/25). The 2 × 2 ANOVA revealed no main effects (Fs < 1). The item-specific PC × Trial Type interaction was not significant, $F < 1$, $p = .370$, $\eta_p^2 = .03$, $BF_{10} = .44$.

Transfer items (PC-50). For transfer items, there were also no main effects (Fs < 1). There was also no significant item-specific PC × Trial Type interaction, $F < 1$, $p = .681$, $\eta_p^2 = .01$, $BF_{10} = .26$.

Performance on memory test. Participants performed well averaging across all pre-Stroop tests ($M = .94$, $SE = .01$). Participants performed equally well on the post-Stroop test ($M = 1.00$, $SE = .00$) as on the last pre-Stroop test ($M = 1.00$, $SE = .00$), and well above chance (.08).

Discussion

The primary theoretical contribution of Experiment 4a was demonstrating that a key contextual factor contributing to the dominance of category-level control in the picture–word Stroop task is the task goal. In the preceding experiments, the task goal was to name the animal in the picture using the category-level name (e.g., "bird") and category-level control dominated in all but one experiment. But in the present experiment the task goal was to name the animal in the picture using the exemplar-level name (e.g., "oriole"), and item-level control now dominated (i.e., there was an ISPC effect for inducer items but not for transfer items). Experiment 4a thus demonstrates that category-level control is not inherently dominant. Furthermore, the task goal may be more critical than the task stimuli (which mimicked the preceding experiments) for biasing adoption of category-level control.

Experiment 4b

We interpreted the findings of Experiment 4a to indicate that *responding* with the exemplar-level names effectively biased

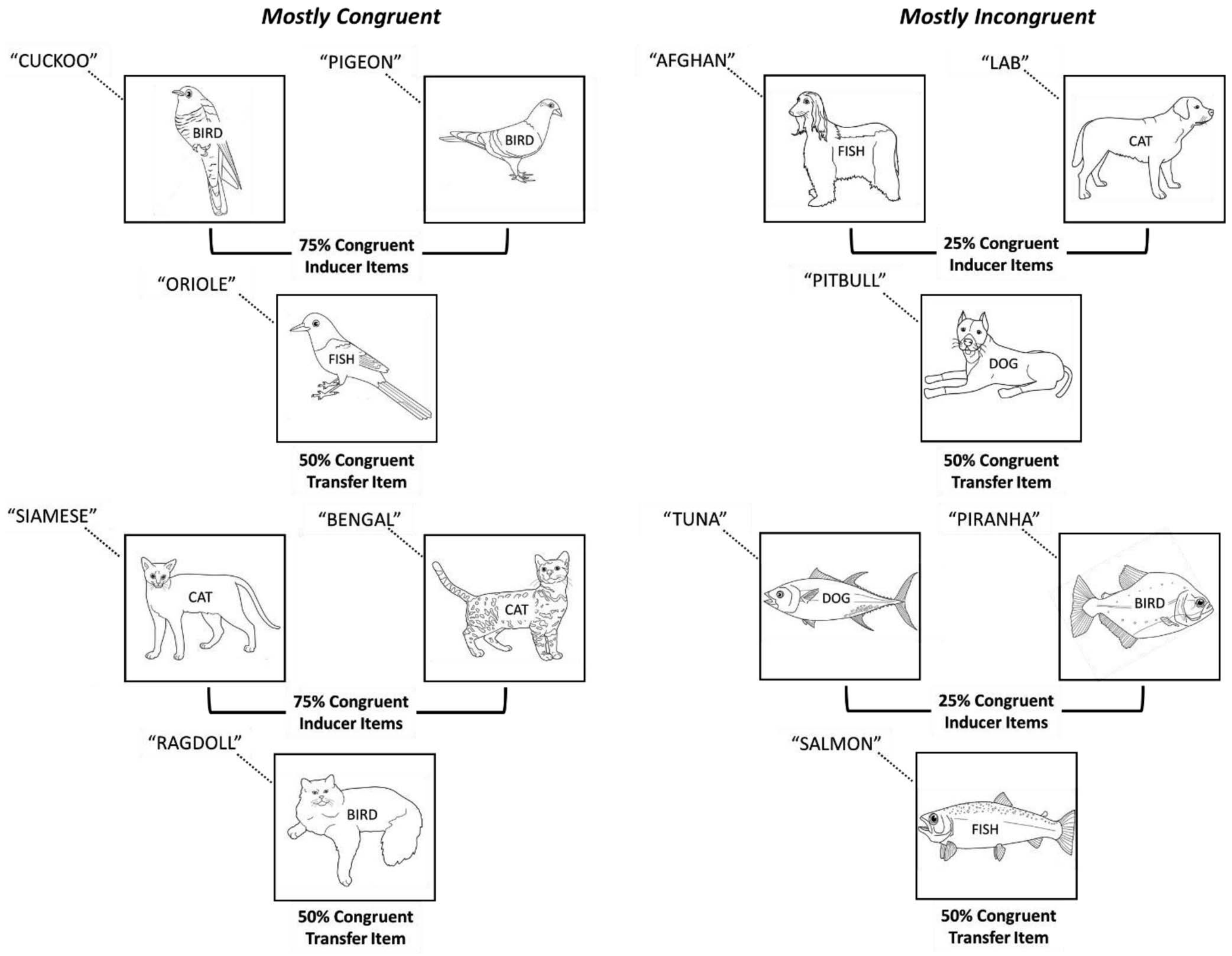

Figure 7. Sample picture–word Stroop stimuli for Experiment 4a. Depicted is one of the counterbalances in which the inducer items for birds and cats were mostly congruent and dogs and fish were mostly incongruent. Transfer items for each animal were unbiased (50% congruent). Participants were asked to respond with the exemplar-level names shown here on the top left of each stimulus.

adoption of item-level control. However, we cannot rule out that the critical factor biasing adoption of item-level control was simply *learning* the exemplar names. Experiment 4b was conducted to examine this possibility. Experiment 4b was identical to Experiment 4a except participants only learned (but did not respond with) the exemplar names. Importantly, Experiment 4b additionally presented an opportunity to gain further traction on two issues. First, theoretically speaking, if the task goal is a critical factor dictating dominance as we have posited, then category-level control should again dominate in the present experiment given that participants' goal was once again to respond with the category-level names as in Experiments 1 through 3.

Second, learning of exemplar-level names may be considered another form of individuation training and therefore an opportunity to replicate the findings of Experiment 3c. Those findings were surprising in light of a prior study (Cañadas et al., 2013) that demonstrated individuation training did bias participants away from use of category-level control in a context-specific PC paradigm. Contrasting Experiment 3b's approach to that of Cañadas et al. (2013), one notable difference was that they encouraged participants to focus on individuating features of the faces *during* the critical (flanker) task. In contrast, we simply had participants engage in individuation training (while learning the pet names for each exemplar) *prior to* the critical (Stroop) task. Any benefits of individuation may be lost as soon as participants begin naming the category-level responses in the Stroop task without further attempts to individuate. Thus, in the present experiment participants were encouraged to focus on the unique features of each animal *during* the Stroop task. If the conclusion of Experiment 3c is generalizable, then we should again find that category-level control dominates even with this form of individuation training. However, if this difference matters, then we may find that individuation training now successfully biases adoption of item-level control.

Table 8
Frequencies of Picture–Word Pairings Collapsed Across All Blocks in Experiment 4a

		Picture											
Item type	Word	Cuckoo	Oriole	Ragdoll	Siamese	Afghan	Pitbull	Salmon	Tuna	Pigeon	Bengal	Lab	Piranha
Inducer	BIRD	27	27	3	3	9	9	9	9				
	CAT	3	3	27	27	9	9	9	9				
	DOG	3	3	3	3	9	9	9	9				
	FISH	3	3	3	3	9	9	9	9				
Transfer													
	BIRD									18	6	6	6
	CAT									6	18	6	6
	DOG									6	6	18	6
	FISH									6	6	6	18

Note. Underlined numbers represent the frequencies of congruent trials (here, for congruent trials the word only matches the category and not the response). The frequencies for all item types were calculated after collapsing across all three blocks of the experiment. The frequencies in this table represent one counterbalance in which the categories of birds and cats are mostly congruent, and dogs and fish are mostly incongruent.

Method

Participants. There were 36 participants (stopping rule was $N = 36$), ranging from 18–22 years of age, from Washington University in St. Louis. Participants were either given class credit or $5 for participating. All participants were native English speakers, had normal or corrected to normal vision, and provided informed consent.

Design and materials. The design and materials were identical to Experiment 4a.

Procedure. The procedure was identical to Experiment 4a with two exceptions, both corresponding to the Stroop phase. One exception was that participants responded with the category-level name (e.g., “bird”) and not the name of the exemplar (e.g., “oriole”). The second exception was that, prior to each block of Stroop trials, participants were instructed to pay attention to the *unique* features of each animal.

Results

The same analyses were performed as in Experiment 4a. Trimming eliminated <1% of the data. Means and standard errors for RT and error rate are displayed in Table 10.

Reaction time.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 35) = 270.24$, $p < .001$, $\eta_p^2 = .89$, such that incongruent trials ($M = 739$ ms, $SE = 13$ ms) were responded to slower than congruent trials ($M = 639$ ms, $SE = 11$ ms). There was also a main effect of item-specific PC, $F(1, 35) = 6.12$, $p = .018$, $\eta_p^2 = .15$, such that MC items ($M = 696$ ms, $SE = 12$ ms) were responded to slower than MI items ($M = 682$ ms, $SE = 12$ ms). These effects were qualified by an item-specific PC × Trial Type interaction (ISPC effect), $F(1, 35) = 6.15$, $p = .018$, $\eta_p^2 = .15$. The Stroop effect was significantly attenuated for the MI items compared with the MC items (see Figure 9).

Transfer items (PC-50). There was a main effect of trial type, $F(1, 35) = 200.38$, $p < .001$, $\eta_p^2 = .85$, such that incongruent trials ($M = 741$ ms, $SE < 14$ ms) were responded to slower than congruent trials ($M = 638$ ms, $SE = 11$ ms). There was also a main effect of item-specific PC, $F(1, 35) = 16.19$, $p < .001$, $\eta_p^2 = .32$, such that transfer items from the MC set ($M = 702$ ms, $SE = 12$ ms) were responded to slower than transfer items from the MI set ($M = 677$ ms, $SE = 13$ ms). Most critically, there was an item-specific PC × Trial Type interaction for the transfer items, $F(1, 35) = 17.046$, $p = .001$, $\eta_p^2 = .33$. The Stroop effect was significantly attenuated for the MI items compared with the MC items (see Figure 9).

Error rate.

Inducer items (PC-75/25). There was a main effect of trial type, $F(1, 35) = 37.02$, $p < .001$, $\eta_p^2 = .51$, such that incongruent trials ($M = .041$, $SE = .006$) had a larger error rate than congruent

Table 9
Mean Reaction Times (ms), Error Rates, and Stroop Effects for Experiment 4a

	MC			MI		
Item type	Congruent	Incongruent	Stroop	Congruent	Incongruent	Stroop
Reaction time						
Inducer	871 (28)	914 (34)	43	878 (28)	891 (29)	13
Transfer	872 (25)	897 (28)	25	883 (26)	892 (26)	9
Error rate						
Inducer	.010 (.003)	.013 (.004)	.003	.014 (.003)	.014 (.004)	.000
Transfer	.013 (.005)	.013 (.004)	.000	.010 (.004)	.008 (.003)	−.002

Note. The standard errors for reaction time and error rates are given within the parentheses. Inducer items were PC-75 and PC-25, respectively, in the mostly congruent (MC) and mostly incongruent (MI) conditions. Transfer items were PC-50 in the MC and in the MI condition.

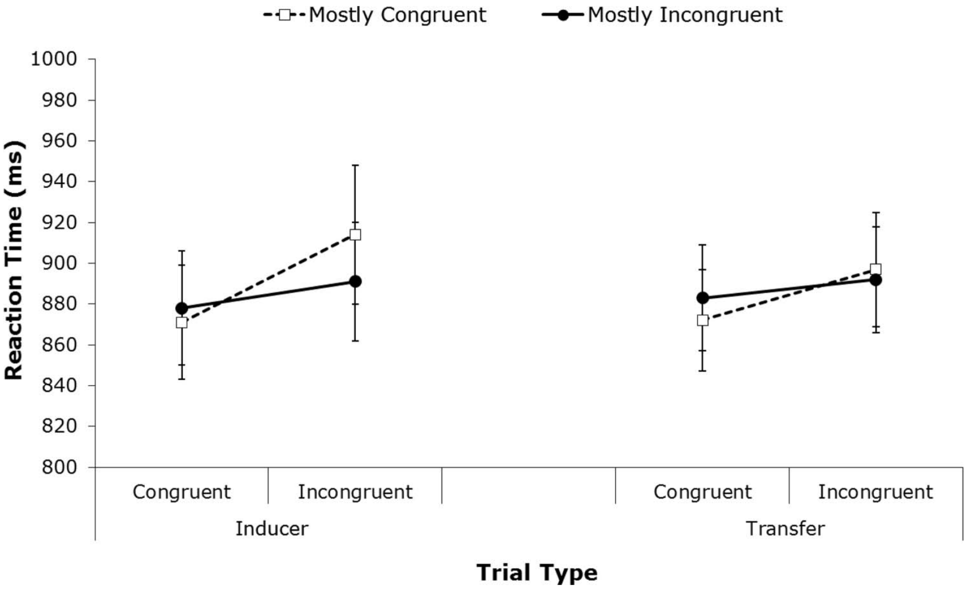

Figure 8. Reaction times on congruent and incongruent trials for inducer and transfer items in Experiment 4a. For inducer items, mostly congruent (MC) and mostly incongruent (MI) refer to PC-75 and PC-25, respectively. For transfer items, MC and MI refer to the PC of the category to which the transfer items belong (PC-67 or PC-33, respectively). Transfer items were 50% congruent at the item level in the MC and MI conditions. Error bars represent standard error of the mean.

trials (M = .010, SE = .002). There was no main effect of item-specific PC, $F < 1$, p = .510, η_p^2 = .01. In addition, there was no item-specific PC × Trial Type interaction, $F(1, 35) = 1.30$, p = .263, η_p^2 = .04, BF_{10} = .32. We take this as evidence indicating that the Stroop effect in error rate did not differ between MC and MI items.

Transfer items (PC-50). There was a main effect of trial type, $F(1, 35) = 25.24$, $p < .001$, η_p^2 = .42, such that incongruent trials (M = .041, SE = .006) had a larger error rate than congruent trials (M = .011, SE = .002). There was no main effect of item-specific PC, $F(1, 35) = 2.08$, p = .158, η_p^2 = .06. In addition, there was no item-specific PC × Trial Type interaction, $F(1, 35) = 1.73$, p = .197, η_p^2 = .05, BF_{10} = 0.51. We take this as evidence indicating that the Stroop effect in error rate did not differ between transfer items that belonged to the MC and MI categories.

Performance on memory test. Averaging across all pre-Stroop tests, participants performed well (M = .92, SE = .01). Participants performed worse on the post-Stroop test (M = .96, SE = .01) than on the last pre-Stroop test (M = 1.00, SE = .00), $t(35)$ = 2.65, p = .012, though performance was well above chance (.08) in all cases.

Discussion

The findings were straightforward. There was an ISPC effect for inducer and transfer items, suggesting use of category-level control. The implications are threefold. First, the findings suggest that consistent with our original interpretation, the critical factor that biased participants to adopt item-level control in Experiment 4a was responding with the exemplar-level names and not simply

Table 10
Mean Reaction Times (ms), Error Rates, and Stroop Effects for Experiment 4b

	MC			MI		
Item type	Congruent	Incongruent	Stroop	Congruent	Incongruent	Stroop
Reaction time						
Inducer	641 (11)	751 (14)	110	637 (12)	728 (13)	91
Transfer	640 (12)	763 (14)	123	635 (12)	720 (15)	85
Error rate						
Inducer	.012 (.002)	.041 (.007)	.029	.007 (.002)	.041 (.006)	.034
Transfer	.012 (.003)	.049 (.007)	.037	.011 (.003)	.033 (.008)	.022

Note. The standard errors for reaction time and error rates are given within the parentheses. Inducer items were PC-75 and PC-25, respectively, in the mostly congruent (MC) and mostly incongruent (MI) conditions. Transfer items were PC-50 in the MC and in the MI condition.

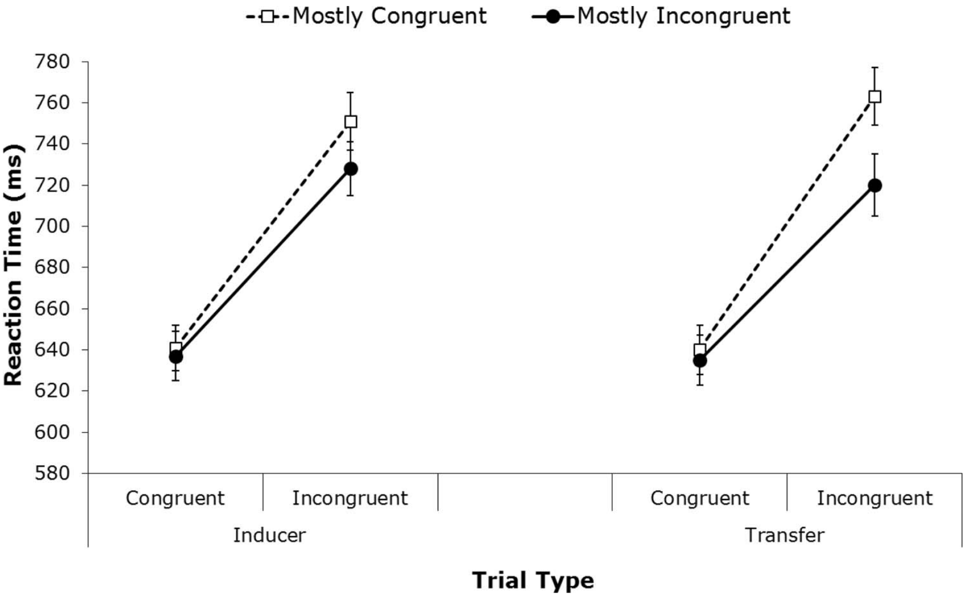

Figure 9. Reaction times on congruent and incongruent trials for inducer and transfer items in Experiment 4b. For inducer items, mostly congruent (MC) and mostly incongruent (MI) refer to PC-75 and PC-25, respectively. For transfer items, MC and MI refer to the PC of the category to which the transfer items belong (PC-67 or PC-33, respectively). Transfer items were 50% congruent at the item level in the MC and MI conditions. Error bars represent standard error of the mean.

learning these names. Second and relatedly, the findings further support our theoretical assumption that the task goal is a critical factor dictating dominance. Using the same exact stimuli (comprising pictures superimposed with category-level names), when the task goal entailed responding with the exemplar-level names (Experiment 4a), item-level control dominated; however, when it entailed responding with the category-level names (Experiment 4b), category-level control dominated. Third, the findings systematically replicated those of Experiment 3c. Individuation training, even with encouragement to focus on unique features of stimuli during the stroop task, did not effectively bias participants to adopt item-level control.

Exploratory Analysis

To gain initial insight into the extent to which there are individual differences in the tendency to use category- versus item-level control in task contexts that tend to bias adoption of category-level control at the group level (Experiments 1, 2, 3b, 3c, and 4b), we created a scatterplot depicting the magnitude of the correlation between the ISPC effect for inducer trials and the ISPC effect for transfer trials (see Figure 10). The correlation was $r(214) = .183$, $p = .007$. However, the primary interest was not the magnitude of the correlation per se but two sets of individuals. We were especially interested in the number of individuals who showed a positive ISPC effect (>0)[9] on inducer trials *and* a positive ISPC effect on transfer trials (i.e., “category-level controllers;” see upper right, light gray shaded area in Figure 10) and the number of individuals who showed the former but not the latter (i.e., “item-level controllers;” see lower right, dark gray shaded area in Figure 10). There were 104 category-level controllers and 45 item-level controllers. This suggests that, although the tendency was (on average) to use category-level control in these three experiments, there were individual differences in this tendency. We discuss these differences further in the General Discussion.

General Discussion

The overarching aim of the present set of experiments was to examine a novel theoretical question using variants of the picture–word Stroop ISPC paradigm: When the potential exists for more than one stimulus-driven control setting to guide the control of attention (here, settings based on category-control or item-control associations), which one prevails? Although category-control associations (i.e., category-level control) dominated, this dominance was dependent on contextual features of the task (i.e., mutable). The findings provide initial insights into the “why” behind the dominance of category-level versus item-level control.

Summary of Findings

In Experiment 1, category-level control dominated (see also Bugg et al., 2011, Experiment 2) despite the presence of design features intended to bias adoption of item-level control (e.g., intermixing of transfer and inducer trials from the beginning; fewer exemplars relative to Bugg et al., 2011; e.g., Hartley &

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[9] We recognize that this criterion is less than ideal. It is hard to argue, for example, that someone who has a -1 ms ISPC effect differs from someone that has a $+1$ ms ISPC effect, or that a $+1$ ms ISPC effect (or even positive values somewhat larger) indicates a meaningful modulation of attention poststimulus onset. However, given the exploratory nature of these analyses, we thought that these contrasts nonetheless offered interesting information that could be pursued further in future research.

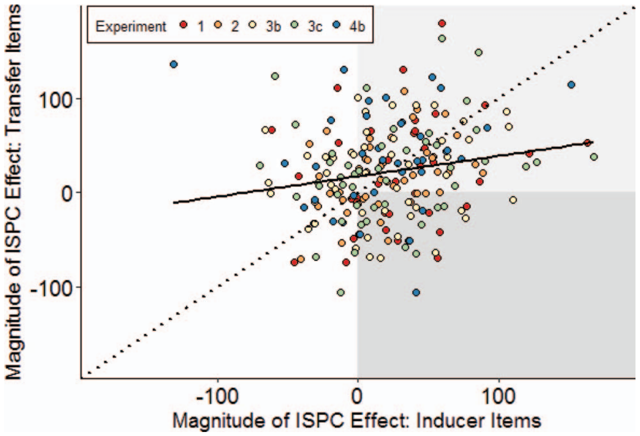

Figure 10. Scatterplot depicting correlation between the item-specific proportion congruence (ISPC) effect ($\mathrm{MC}_{\text{Stroop effect}} - \mathrm{MI}_{\text{Stroop effect}}$) for inducer items and the ISPC effect for transfer items collapsed across the five experiments in which category-level control was dominant (Experiments 1, 2, 3b, 3c, and 4b). The dots within the light gray box (upper right) and dark gray box (lower right) represent participants who showed a "positive" (>0) ISPC effect for inducer items. However, only dots within the lighter of the two boxes represent participants who also showed a "positive" ISPC effect for transfer items. We refer to these participants as "category-level controllers" and those in the dark gray box as "item-level controllers." See the online article for the color version of this figure.

Homa, 1981; Homa, 1978), as evidenced by an ISPC effect for transfer items in addition to inducer items. In Experiment 2, the dominance of category-level control persisted even for a subset of transfer items for which the item-level control setting *conflicted* with the category-level control setting. Indeed, regardless of whether the transfer item was consistent or inconsistent with the category, the item triggered retrieval of the category-level control setting, producing transfer. Collectively, these findings suggested a pervasive tendency to engage category-level control rather than item-level control when these two stimulus-driven control settings compete. The remainder of the experiments examined whether it was possible to bias adoption of item-level control under task conditions where category-level control routinely dominates.

Experiment 3a successfully shifted the dominance. In this experiment, participants engaged in a recategorization phase prior to the Stroop task whereby a competing category was introduced (i.e., pet owner) and the boundaries between the animal categories were blurred by assigning one type of each animal (bird, cat, dog, and fish) to each pet owner. Although recategorization clearly exposed participants to (i.e., familiarized them with) the stimuli prior to the Stroop task and required participants to discriminate among the exemplars within each animal category (otherwise, they could not learn which bird, cat, etc. was associated with which pet owner), Experiments 3b and 3c, respectively, demonstrated that neither exposure or individuation training (i.e., differentiating among exemplars by learning an arbitrary pet name for each exemplar such as "Zippy") on their own successfully biased participants away from learning and using category-control associations. The implication is that the presence of a competing category is a critical factor for disrupting category-level control.

In four of the first five experiments, category-level control prevailed, and those five experiments used the same stimuli (animal pictures from preexisting categories superimposed with irrelevant words at the category level) and the same task goal (naming the animal in the picture using the category-level name). Consequently, it seemed plausible that these task factors may contribute to the dominance of category-level control (as opposed to it being inherently dominant). In an initial test of this view, Experiment 4a altered the task goal but kept the nature of the stimuli the same as the previous experiments. The goal was to name the animal in the picture using the exemplar-level name (e.g., "lab," "oriole") instead of the category name (e.g., "dog," "bird"). Under these conditions, item-level control prevailed. There was no transfer of the ISPC effect to 50% congruent items. Finally, Experiment 4b confirmed that the typical pattern (i.e., use of category-level control) reemerged when participants learned the names of the exemplars (e.g., lab, oriole, etc.) but again responded using the category name. This experiment was additionally important in providing converging evidence to support the conclusion of Experiment 3c that individuation training (in Experiment 4b, this involved actively differentiating among exemplars by learning which exemplar was the lab, pitbull, etc.) is not sufficient to bias adoption of item-level control in the present task context. Notably, this was the case even though we additionally encouraged participants to focus on unique features of the animals *during* the Stroop task (cf. Cañadas et al., 2013). Collectively, the findings of these seven experiments demonstrated that category-level control appears to be quite dominant but under select conditions, this dominance is mutable. In the next section we integrate these findings to inform a preliminary account of the dominance of one level of control relative to another.

Factors That May Propel Category-Level Control to (Generally) Win the Competition

The fact that the dominance of category-level control was mutable suggests that category-level control is not inherently dominant. What then explains the dominance of one level of control over another? In other words, why were participants generally more apt to rely on category-level signals but, in select conditions, relied on item-level signals? It does not seem that a simple efficiency explanation (i.e., categories represent a more efficient means of storing and retrieving control settings than engaging these processes for each item one encounters) suffices because category-level control did not dominate in every experiment. A useful approach to addressing this question may be to draw on tectonic theory (Melara & Algom, 2003). This theory exquisitely highlighted critical factors that attract attention to distractors (irrelevant words) and thereby impede selective attention to the target (e.g., color) in the Stroop task. Previously, the dual item-specific mechanism account of ISPC effects (Bugg, 2015; Bugg & Hutchison, 2013; Bugg et al., 2011) capitalized on this theory to anticipate the experimental conditions that would draw attention to the irrelevant dimension (word), thereby producing contingency-based ISPC effects, or the relevant dimension (e.g., picture), thereby producing control-based ISPC effects (as in the present designs). Similarly, tectonic theory may be valuable for understanding the question of current interest: When and why does attention orient to the category feature of the relevant dimension as compared with the item feature of the relevant dimension to guide control? Two main tectonic factors warrant consideration: correlated information (informative-ness) and salience.[10] Applied to the present question, correlated information refers to how informative the item versus category was with respect to proportion congruence whereas salience refers to whether the psychophysical and production contexts favored discrimination of category values or item values.

Regarding correlated information, the item and category signals were equally correlated with proportion congruence (and thus equally informative) for inducer items. That is, both the item and the category predicted that the stimulus would be 75% or 25% congruent. This means that the dominance of category-level control does not appear to be attributable to informative-ness. Indeed, the purpose was to put two informative ISPC signals (item vs. category) in competition to see which one would dominate. Only when one considers the 50% congruent transfer items on their own is there evidence that category-level information was more useful (categories predicted the stimulus would be 67% or 33% congruent whereas the item itself predicted 50% congruent for transfer items). However, this was true for Experiments 1, 3a, 3b, 3c, 4a, and 4b but category-level control did not dominate in every experiment. Moreover, this was not true in Experiment 2 where inconsistent transfer items were 83% or 17% congruent yet category-level control did dominate even for those items. Thus, while we cannot rule out that correlated information made some contribution to the dominance of categories over items, informative-ness does not appear to be the entire story.

Turning to salience, in the typical variant of the ISPC picture–word Stroop task (e.g., Experiments 1, 2, 3a, 3b, 3c, and 4b; Bugg et al., 2011) the most salient feature may be the animal category because of contextual features of the task including (a) the nature of the stimuli (i.e., categories represented by the pictures are known to participants [they are preexisting] and the relatively automatically processed word refers to the animal category); and (b) the task goal (participants respond by using the category-level names [e.g., "bird"]). In Experiment 3a, recategorization, and particularly the presence of a competing category (pet owner), may have served to decrease the salience of the animal category (cf. Gaertner et al., 1989) allowing item-level control to prevail. That is, recategorization may have overrode the typical influence of these contextual factors in producing category-level control.

The results of Experiment 4a can also be viewed through the lens of a salience account. In this experiment, we changed the task goal such that participants responded by using the exemplar-level names (e.g., "oriole") instead of the category-level names (e.g., "bird"). The change in task goal may have served to continuously heighten the salience of exemplar representations *during* the Stroop task, thereby shifting dominance to the item level. For example, it may be that the accumulation of conflict signals, on which learning of stimulus-control associations depends, tends to occur at the "level" at which responses are emitted. This possibility is consistent with all but one experiment (i.e., category-level dominance with category-level responses in Experiments 1, 2, 3b, 3c, and 4b and item-level dominance with item-level responses in Experiment 4a, but not Experiment 3a). The idea that multiple factors contribute to salience meshes with findings based on tectonic theory showing that elements of the psychophysical context (here, how discriminable values of the category are relative to the item, as in Experiment 3a) and elements of the production context (here, whether responding is at the category or exemplar level, as in Experiment 4a) contribute to salience (Melara & Algom, 2003; Melara & Mounts, 1993).

There are three additional points that merit mention with respect to the salience account. First, regarding the idea that multiple contextual factors affect salience (and thereby the dominance of category- relative to item-level control), there may be a hierarchy such that some factors are more important than others. It appears, for example, that the nature of the stimuli may be less important in the present context than the task goal. The clearest evidence supporting this view stems from the findings of Experiments 4a and 4b. The stimuli were identical in both experiments, yet item-level control dominated selectively in Experiment 4a when the task goal required exemplar-level responses.

Second, although the above interpretation suggests that the change in task goal was the critical factor biasing adoption of item-level control in Experiment 4a, the change in task goal also coincided with a change in the locus (i.e., due to the absence of overlap between the irrelevant words and responses) and thereby magnitude of the Stroop effect. Given that there was an ISPC effect on inducer trials and it mirrored the pattern observed in all other experiments (asymmetrical with stronger effect on incongruent trials), we are doubtful that the overall reduction in the magnitude of the Stroop effect was the critical factor biasing adoption of item-level control. However, at present we cannot rule out the possibility that the change in the locus of the effect could instead be the critical factor (rather than the change in the task goal).

Third, the interpretation of the present findings from the perspective of the salience account suggests that category-level control is not inherently dominant, but rather context-dependent. Thus far, we primarily have considered how perceptual features of the stimuli and task goals affect the salience of category and item-level signals (cf. Taylor & Fiske, 1978). The type of training (i.e., strategy) introduced prior to the Stroop task merits additional consideration. Two different forms of individuation training did not bias adoption of item-level control, including one that encouraged participants to focus on unique features of the animal during the Stroop task. This was surprising considering the findings of Cañadas et al. (2013) and may also seem surprising from the perspective of the salience account. A priori it could be anticipated that individuation should heighten the salience of exemplars (items) relative to the animal categories, leading to item-level control. In hindsight, this may be easier said than done in the present task context. In Cañadas et al. (2013), the PC-predictive feature (face depicting male or female gender) that participants were instructed to individuate was presented 400 ms before presentation of the imperative (flanker) stimulus to which responses were made. In contrast, in the present research, participants had to individuate pictures they were also attempting to name. That is, the act of individuation had to occur simultaneously with the presentation of the imperative (Stroop) stimulus. Moreover, in Cañadas et al. (2013), responses to the imperative stimuli were unrelated to the gender category of the face whereas in the present research, responses to the imperative stimuli referred directly to the animal

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[10] We use the term "salience" for consistency with tectonic theory. Our use of this term includes not just information that is perceptually salient (as in attention grabbing) but also non-perceptual features that affect salience such as a task goal.

category. Thus, despite attempts to individuate the stimuli before and/or during the Stroop task, the category may have remained quite salient. One interpretation is that individuation may heighten the salience of item representations, but its effectiveness in promoting item-level control may be limited in certain task contexts. That recategorization was, in contrast, effective prompts consideration of another interpretation. The success of recategorization was shown to be related to the presence of a competing category. This may suggest that degrading the salience of preexisting categories (e.g., by introducing a competing category that blurs preexisting boundaries) is more effective for biasing participants against the learning and/or use of category-level control than is attempting to increase the salience of exemplars within those categories (i.e., via individuation). An exciting endeavor for future research will be to explore the interactivity of the various contextual factors (i.e., stimuli, goals, type of training) to develop a more nuanced account of the role of salience in dictating the dominance of one versus another stimulus-driven control setting.

Implications for Theoretical Accounts and Computational Models

The present findings fit well with accounts suggesting control can operate at multiple levels (e.g., Braver et al., 2007), including multiple stimulus-driven (reactive) levels (Bugg, 2012; Bugg, 2017; Bugg & Crump, 2012; Bugg et al., 2011, 2008). Prior theorizing has acknowledged the operation of three levels of control, listed here from the most global to the most selective: the list level (as observed with some list-wide PC manipulations; e.g., Bugg, 2014b; Bugg & Chanani, 2011; Gonthier, Braver, & Bugg, 2016; Hutchison, 2011), the context level (as observed with context-specific PC manipulations; e.g., Crump & Milliken, 2009), and the item level (as observed with item-specific PC manipulations; e.g., Bugg & Hutchison, 2013; Bugg et al., 2011). The present experiments found evidence for the latter, item level (Experiments 3a and 4a); however, the dominant level of control in the present ISPC paradigm was the category level. This raises the question of where category-level control fits into extant conceptualizations of control.

One possibility is that category-level control, like context-level control, is another “intermediate” level between global and item-level control. Of course, this leads to the question of whether these two levels are redundant such that a three-level model of control continues to suffice in explaining extant effects. In line with this possibility, it may be that both levels of control are stimulus-driven with the signal that triggers retrieval of control settings being a categorical signal. This notion of a category-based representation guiding control in context-specific PC paradigms finds support in two flanker studies, one being the Cañadas et al. (2013) study (gender as a contextual cue) that was reviewed earlier and the second being Weidler and Bugg (2016). Weidler and Bugg found transfer of context-level control from a set of trained (biased as MC or MI) locations on screen to a separate set of unbiased transfer locations that fell within the same *category* of space as the trained locations.

Another possibility is that the context and category levels of control are distinct, and both should be represented in extant accounts. Conceptually speaking, the manipulations do involve clear differences. In the context-specific PC manipulation, the PC signal is a contextual cue that is nominally irrelevant to task performance and not a feature of the task stimuli (e.g., gender of a face that precedes the onset of flanker stimuli; location on screen in which flanker stimuli are presented) whereas the ISPC manipulation that produces category-level control entails a PC signal that is relevant to performance and a feature of the task stimuli (e.g., the picture). This is illustrated in Figure 11 where the top panel displays a potential context-specific PC manipulation using the same picture–word stimuli used for the ISPC manipulation in the present study (bottom panel). As discussed above, differences between the manipulations may have contributed to the divergent effects of individuation training on limiting use of category-based control in the present ISPC paradigm relative to the context-specific PC paradigm.

In addition to this difference, there are other notable differences that argue against redundancy. For instance, one characteristic that describes the “intermediate” level of control is that it appears to afford an optimum level of flexibility. Unlike the global level, which is completely indiscriminating (i.e., applies a uniform control setting to all stimuli in a list/block including those for which it is not optimal; Gonthier et al., 2016), and the item level, which is perhaps too specific, the intermediate level seems just right. It enables attentional adjustments to occur optimally based on the current category or context *and* flexibly, such that adjustments occur not just when past stimuli are encountered but additionally when unique stimuli are encountered from a past category or context. Transfer, thus, seems to be a critical signature of the intermediate level of control. There is presently mixed evidence for transfer of context-level control to unique stimuli. For instance, Crump and Milliken (2009) demonstrated transfer from biased inducer stimuli to unique PC-50 stimuli presented in the same locations (and thus sharing the context-PC signal; cf. Cañadas et al., 2013) but that effect has not been consistently reproduced (Hutcheon & Spieler, 2017; but see, Crump, Brosowsky, & Milliken, 2017). In contrast, transfer of category-level control to unique PC-50 stimuli from the same category has been thus far consistently observed in those conditions anticipated to produce it (Bugg et al., 2011; present experiments). Yet, to our knowledge, no study has contrasted context-level and category-level control in the same study. Accordingly, the jury must remain out until more direct comparisons are made behaviorally or at a neural level (e.g., using the approaches of Chiu et al., 2017; King, Korb, & Egner, 2012) in future research.

The present findings also have implications for extant computational models that accommodate ISPC effects. The item-specific conflict monitoring model (Blais, Robidoux, Risko, & Besner, 2007) posits that conflict is monitored at the item level and control adjustments are item specific. The conflict-modulated Hebbian learning account of control similarly monitors and adjusts attention based on learning that occurs at the item level (Verguts & Notebaert, 2008). The present findings are for the large part compatible with these accounts. Indeed, as Bugg et al. (2011) noted, the asymmetrical control-based ISPC pattern (bigger effect of the ISPC manipulation on the incongruent trials) accords well with the conflict-modulated nature of these models. The models may, however, have difficulty handling the evidence for transfer based on category-level control in Experiments 1, 2, 3b, 3c, and 4b. To accommodate the transfer effects, a modification should be made

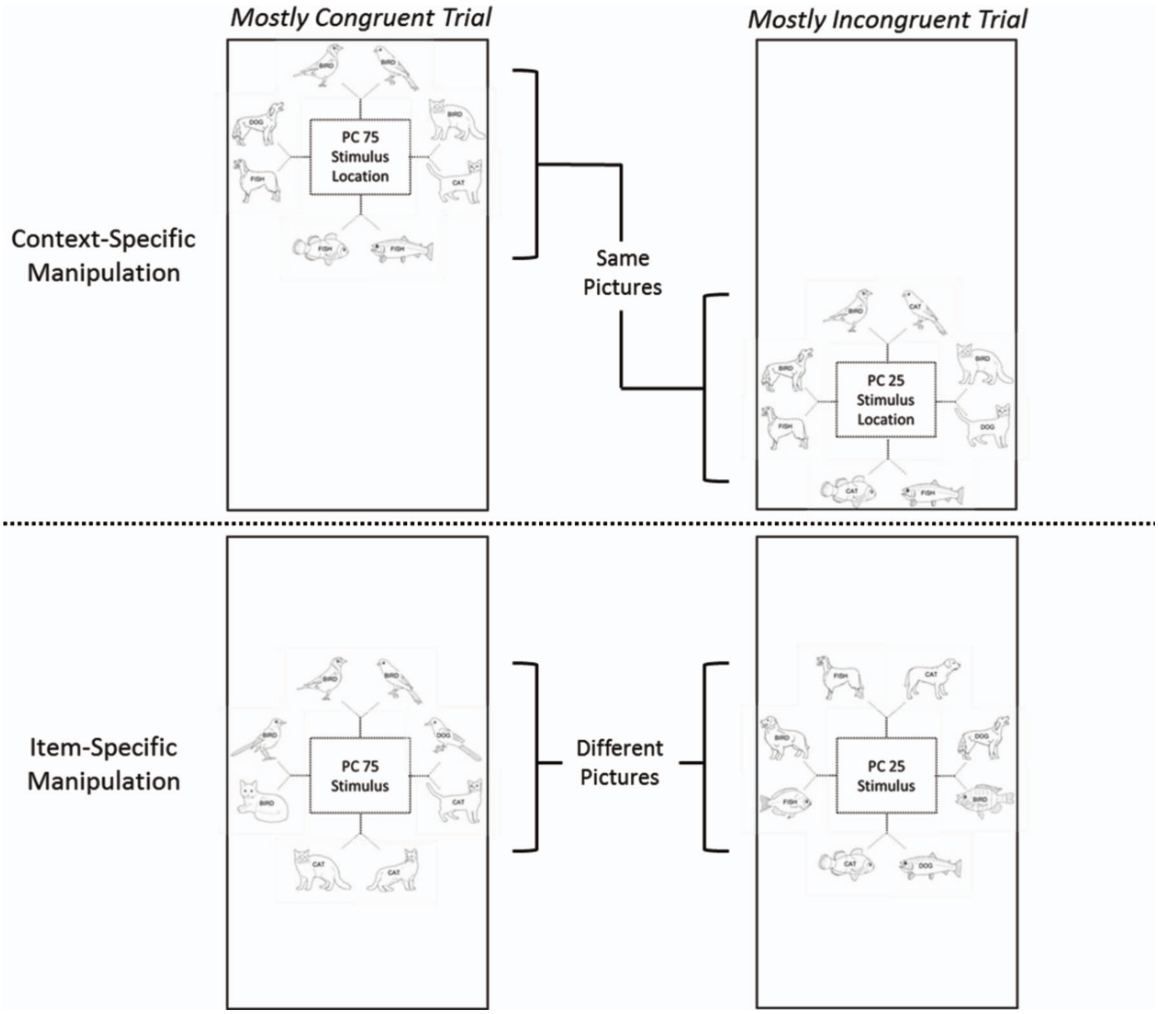

Figure 11. Depictions of two types of proportion congruence manipulations: context-specific (upper panel) and item-specific (lower panel). At the context level, the picture stimuli are presented in an upper (e.g., MC) or lower (e.g., MI) location of the screen, for example. The same exact pictures appear in the MC and MI condition: They are simply presented disproportionately more frequently as congruent or incongruent trials, respectively. At the item level, the picture stimuli are presented in one location. One set of picture stimuli (e.g., birds and cats) is MC and one set (e.g., dogs and fish) is MI such that critically, on MC trials the pictures differ from MI trials. For both manipulations, the list-wide PC is 50%.

to include category-level nodes that can accumulate conflict and signal the need for control at the category instead of the item level.

The present findings are also important for these and other accounts that consider the role of learning in cognitive control (e.g., Abrahamse et al., 2016; Egner, 2014). As noted in the Introduction, it is an open question of which stimulus features get bound to control settings during learning and effectively trigger retrieval of control settings. It is critical for a model to anticipate such features; otherwise, the model cannot predict which stimuli will or will not trigger stimulus-driven attentional adjustments. The current findings suggest that informative-ness (whether a feature is predictive of PC) may be a prerequisite for binding (i.e., only features that are predictive of PC get bound), but some stimulus features dominate over others. If future studies confirm the role of salience in this dominance, extant models can be adjusted to weight features differentially based on their salience with more heavily weighted features driving learning and retrieval of control settings. This would allow models to account for the shifting dominance of category as compared with item-level control across experiments.

Finally, although the goal of the present experiments was not to test the contingency account of ISPC effects, a few points are notable with respect to this account. The present experiments all adopted the design in which the relevant dimension signals ISPC and produces a control-based ISPC effect (Bugg et al., 2011; Chiu et al., 2017). Accordingly, when ISPC effects were observed in the present experiments, they were characterized by the behavioral signature indicative of item-level control as opposed to item-specific contingency learning. That signature is the asymmetrical effect in which the primary difference between the MC and MI conditions is on incongruent (conflict-laden) trials. A key point, then, is that while the ISPC pattern on inducer trials may be used to dissociate control from contingency (Bugg et al., 2011; Chiu et al., 2017), the ISPC pattern on inducer trials is unable to distinguish use of category-level control from use of item-level control—one must also examine whether there is an ISPC effect on transfer trials (which uniquely implicates category-level control).

Limitations and Future Directions

One limitation of the present research is that it employed a single ISPC paradigm—the picture–word Stroop paradigm (Bugg et al., 2011). The advantages of choosing this paradigm were twofold: First, because the research question of interest in the present experiments concerned competition between control settings and not contingency (S-R) learning, it was necessary to utilize an ISPC paradigm that produces control-based ISPC effects (Bugg, 2014a; Bugg et al., 2011; Chiu et al., 2017). Second, the research question hinged on use of a paradigm in which more than one level of stimulus-driven control could operate, and there was preliminary evidence suggesting item-level and category-level control could operate in this paradigm (Bugg et al., 2011). Nonetheless, future research is needed to directly evaluate the potential for category-level and item-level control to influence performance in other ISPC paradigms, such as the color–word paradigm in which the color (relevant dimension) serves as the ISPC signal (Bugg & Hutchison, 2013). It is not implausible that category-level control could operate in this paradigm. Participants may, for example, show transfer effects such that they apply the control setting associated with "blue" items to other blue hues besides those that were trained. As in Experiment 4a of the present study, this transfer may not be observed if participants responded with the "exemplar-level" name of each blue hue (e.g., "navy," "royal").

A second limitation concerns our suggestion that stimulus-driven control settings are in competition. Competition might imply that both settings are retrieved and actively competing to guide attention poststimulus onset. However, we have no means of confirming this behaviorally. It may be equally or more valid to formulate the question as one that is concerned with which stimulus-control association tends to be formed (learned) and thus dominates during the Stroop task. It is possible that the competition, so to speak, is won early during the task. For instance, in Experiments 1, 2, 3b, 3c, and 4b participants may have learned only category-control associations for each stimulus and not item-control associations. If so, then categories and items competed for attention only initially, with perhaps the more salient of the two winning out. The question is theoretically interesting regardless of whether the competition is resolved early (during initial learning) or continues to emerge each time a stimulus is presented throughout the task, but new methods will be needed to tease apart these possibilities.

An important future direction is to examine the potential for the basic research presented herein to inform our understanding of cognitive processes that contribute to reliance on category-level rather than individual-level representations, such as in the context of stereotyping, where stimulus-driven control settings can collide. For example, based on past experiences one may have learned associations between a social category (e.g., racial category "A") and an attentional setting (e.g., attend to person in a cautious way) and between a given person (i.e., item) and an attentional setting (e.g., attend to person in a relaxed way). Suppose the person is a member of Racial Category A—when encountering this person unexpectedly, the findings of Experiment 2 suggest that the (nonoptimal) category-level control setting will be retrieved and thus guide the interaction. Experiment 3a, however, raises the possibility that recategorization (e.g., associating members of different racial categories with new categories such as Team A, Team B, and Team C; cf. Gaertner et al., 1989) prior to the encounter could potentially shift the dominance, such that the individual-level control setting is instead retrieved. Taken together, these findings raise interesting questions concerning the extent to which "training" or "strategies" may modify the tendency of the cognitive system to learn and retrieve attentional settings at the category-level, a tendency that operates outside participants' awareness (i.e., implicitly). However, we can only speculate about these applications until future research examines whether our findings using animal stimuli generalize to social stimuli.

Future research should also investigate how flexibly individuals can shift between item- and category-level control. Our experiments demonstrated the dominance of one level of control over the other in different experimental contexts but did not show that a given individual can "switch" from utilizing category to utilizing item-level control or vice versa. Experiments in which participants are first exposed to the typical procedure (e.g., Experiment 1 design) prior to undergoing recategorization may potentially address this question. A second question that is critical to address for both theoretical and applied purposes concerns individual differences. The exploratory analyses indicated that there are individual differences in the tendency to rely on category- as opposed to item-level control (see Figure 10). How stable are these tendencies? Is it the case that category-level controllers in a paradigm such as the present picture–word Stroop task also tend to be category-level controllers in other paradigms, including those that are closely related (e.g., context-specific PC paradigm where categories can guide control; Cañadas et al., 2013) and those that are distinct (e.g., implicit association tasks). If the answer is "yes," this would suggest that processes such as stereotyping may partly be driven by tendencies of individuals to prefer category-based processing regardless of whether the task involves judgments of social categories. This may lead to unique training approaches for modifying tendencies that could produce discriminatory behavior.

Conclusion

To conclude, across seven experiments, we examined the following question: When more than one stimulus-control association is available to guide attention (i.e., when more than one stimulus-driven control setting exists), which one wins the competition (i.e., dominates)? The findings suggested that category-level control, as opposed to item-level control, tended to dominate in the present task context. Use of category-control associations enabled highly flexible, stimulus-driven control that transferred beyond inducer (trained) items to unique exemplars from trained categories. The dominance of category-level control was not, however, immutable as use of recategorization or a task goal requiring responding at the exemplar-level biased adoption of item-level control. We proposed an account suggesting that dominance appears to depend on contextual factors that may influence the salience of category-level relative to item-level representations. The novel findings presented herein suggest modifications to current computational models of cognitive control and encourage continued investigation of the role of categorical representations in guiding attention in other task contexts (cf. visual search, Chua & Gauthier, 2016).

References

Abrahamse, E., Braem, S., Notebaert, W., & Verguts, T. (2016). Grounding cognitive control in associative learning. *Psychological Bulletin, 142,* 693–728. http://dx.doi.org/10.1037/bul0000047

Atalay, N. B., & Misirlisoy, M. (2012). Can contingency learning alone account for item-specific control? Evidence from within- and between-language ISPC effects. *Journal of Experimental Psychology, 38,* 1578–1590. http://dx.doi.org/10.1037/a0028458

Blais, C., Robidoux, S., Risko, E. F., & Besner, D. (2007). Item-specific adaptation and the conflict-monitoring hypothesis: A computational model. *Psychological Review, 114,* 1076–1086. http://dx.doi.org/10.1037/0033-295X.114.4.1076

Braver, T. S., Gray, J. R., & Burgess, G. C. (2007). Explaining the many varieties of working memory variation: Dual mechanisms of cognitive control. In A. R. A. Conway, C. Jarrold, M. J. Kane, A. Miyake, & J. N. Towse (Eds.), *Variation in working memory* (pp. 76–106). New York, NY: Oxford University Press.

Bugg, J. M. (2012). Dissociating levels of cognitive control: The case of Stroop interference. *Current Directions in Psychological Science, 21,* 302–309. http://dx.doi.org/10.1177/0963721412453586

Bugg, J. M. (2014a). Evidence for the sparing of reactive cognitive control with age. *Psychology and Aging, 29,* 115–127. http://dx.doi.org/10.1037/a0035270

Bugg, J. M. (2014b). Conflict-triggered top-down control: Default mode, last resort, or no such thing? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 567–587. http://dx.doi.org/10.1037/a0035032

Bugg, J. M. (2015). The relative attractiveness of distractors and targets affects the coming and going of item-specific control: Evidence from flanker tasks. *Attention, Perception & Psychophysics, 77,* 373–389. http://dx.doi.org/10.3758/s13414-014-0752-x

Bugg, J. M. (2017). Context, conflict, and control. In T. Egner (Ed.), *The Wiley handbook of cognitive control* (pp. 79–96). Chichester, UK: Wiley. http://dx.doi.org/10.1002/9781118920497.ch5

Bugg, J. M., & Chanani, S. (2011). List-wide control is not entirely elusive: Evidence from picture-word Stroop. *Psychonomic Bulletin & Review, 18,* 930–936. http://dx.doi.org/10.3758/s13423-011-0112-y

Bugg, J. M., & Crump, M. J. C. (2012). In support of a distinction between voluntary and stimulus-driven control: A review of the literature on proportion congruent effects. *Frontiers in Psychology, 3,* 367. http://dx.doi.org/10.3389/fpsyg.2012.00367

Bugg, J. M., & Hutchison, K. A. (2013). Converging evidence for control of color-word Stroop interference at the item level. *Journal of Experimental Psychology: Human Perception and Performance, 39,* 433–449. http://dx.doi.org/10.1037/a0029145

Bugg, J. M., Jacoby, L. L., & Chanani, S. (2011). Why it is too early to lose control in accounts of item-specific proportion congruency effects. *Journal of Experimental Psychology: Human Perception and Performance, 37,* 844–859. http://dx.doi.org/10.1037/a0019957

Bugg, J. M., Jacoby, L. L., & Toth, J. P. (2008). Multiple levels of control in the Stroop task. *Memory & Cognition, 36,* 1484–1494. http://dx.doi.org/10.3758/MC.36.8.1484

Cañadas, E., Rodríguez-Bailón, R., Milliken, B., & Lupiáñez, J. (2013). Social categories as a context for the allocation of attentional control. *Journal of Experimental Psychology: General, 142,* 934–943. http://dx.doi.org/10.1037/a0029794

Chiu, Y. C., Jiang, J., & Egner, T. (2017). The caudate nucleus mediates learning of stimulus-control state associations. *The Journal of Neuroscience, 37,* 1028–1038. http://dx.doi.org/10.1523/JNEUROSCI.0778-16.2016

Chua, K. W., & Gauthier, I. (2016). Category-specific learned attentional bias to object parts. *Attention, Perception, & Psychophysics, 78,* 44–51. http://dx.doi.org/10.3758/s13414-015-1040-0

Crump, M. J. C. (2016). Learning to selectively attend from context-specific attentional histories: A demonstration and some constraints. *Canadian Journal of Experimental Psychology, 70,* 59–77. http://dx.doi.org/10.1037/cep0000066

Crump, M. J. C., Brosowsky, N. P., & Milliken, B. (2017). Reproducing the location-based context-specific proportion congruent effect for frequency unbiased items: A reply to Hutcheon and Spieler (2016). *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 70,* 1792–1807. http://dx.doi.org/10.1080/17470218.2016.1206130

Crump, M. J. C., Gong, Z., & Milliken, B. (2006). The context-specific proportion congruent Stroop effect: Location as a contextual cue. *Psychonomic Bulletin & Review, 13,* 316–321. http://dx.doi.org/10.3758/BF03193850

Crump, M. J. C., & Milliken, B. (2009). The flexibility of context-specific control: Evidence for context-driven generalization of item-specific control settings. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 62,* 1523–1532. http://dx.doi.org/10.1080/17470210902752096

Crump, M. J. C., Vaquero, J. M. M., & Milliken, B. (2008). Context-specific learning and control: The roles of awareness, task relevance, and relative salience. *Consciousness and Cognition, 17,* 22–36. http://dx.doi.org/10.1016/j.concog.2007.01.004

Diede, N. T., & Bugg, J. M. (2017). Cognitive effort is modulated outside of the explicit awareness of conflict frequency: Evidence from pupillometry. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 43,* 824–835. http://dx.doi.org/10.1037/xlm0000349

Egner, T. (2014). Creatures of habit (and control): A multi-level learning perspective on the modulation of congruency effects. *Frontiers in Psychology, 5,* 1247. http://dx.doi.org/10.3389/fpsyg.2014.01247

Entel, O., Tzelgov, J., & Bereby-Meyer, Y. (2014). Proportion congruency effects: Instructions may be enough. *Frontiers in Psychology, 5,* 1108. http://dx.doi.org/10.3389/fpsyg.2014.01108

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175–191.

Gaertner, S. L., Mann, J., Murrell, A., & Dovidio, J. F. (1989). Reducing intergroup bias: The benefits of recategorization. *Journal of Personality and Social Psychology, 57,* 239–249. http://dx.doi.org/10.1037/0022-3514.57.2.239

Gonthier, C., Braver, T. S., & Bugg, J. M. (2016). Dissociating proactive and reactive control in the Stroop task. *Memory & Cognition, 44,* 778–788. http://dx.doi.org/10.3758/s13421-016-0591-1

Hartley, J., & Homa, D. (1981). Abstraction of stylistic concepts. *Journal of Experimental Psychology: Human Learning and Memory, 7,* 33–46. http://dx.doi.org/10.1037/0278-7393.7.1.33

Homa, D. (1978). Abstraction of ill-defined form. *Journal of Experimental Psychology: Human Learning and Memory, 4,* 407–416. http://dx.doi.org/10.1037/0278-7393.4.5.407

Hugenberg, K., Miller, J., & Claypool, H. M. (2007). Categorization and individuation in the cross-race recognition deficit: Toward a solution to an insidious problem. *Journal of Experimental Social Psychology, 43,* 334–340. http://dx.doi.org/10.1016/j.jesp.2006.02.010

Hutcheon, T. G., & Spieler, D. H. (2017). Limits on the generalizability of context-driven control. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 70,* 1292–1304. http://dx.doi.org/10.1080/17470218.2016.1182193

Hutchison, K. A. (2011). The interactive effects of listwide control, item-based control, and working memory capacity on Stroop performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 851–860. http://dx.doi.org/10.1037/a0023437

Jacoby, L. L., Lindsay, D. S., & Hessels, S. (2003). Item-specific control of automatic processes: Stroop process dissociations. *Psychonomic Bulletin & Review, 10,* 638–644. http://dx.doi.org/10.3758/BF03196526

JASP. (2014). [Computer software]. Retrieved from http://jasp-stats.org/

King, J. A., Korb, F. M., & Egner, T. (2012). Priming of control: Implicit contextual cuing of top-down attentional set. *The Journal of Neuroscience, 32,* 8192–8200. http://dx.doi.org/10.1523/JNEUROSCI.0934-12.2012

Lamers, M. J. M., Roelofs, A., & Rabeling-Keus, I. M. (2010). Selective attention and response set in the Stroop task. *Memory & Cognition, 38,* 893–904. http://dx.doi.org/10.3758/MC.38.7.893

Lebrecht, S., Pierce, L. J., Tarr, M. J., & Tanaka, J. W. (2009). Perceptual other-race training reduces implicit racial bias. *PLoS ONE, 4,* e4215. http://dx.doi.org/10.1371/journal.pone.0004215

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review, 95,* 492–527. http://dx.doi.org/10.1037/0033-295X.95.4.492

Logan, G. D. (2002). An instance theory of attention and memory. *Psychological Review, 109,* 376–400. http://dx.doi.org/10.1037/0033-295X.109.2.376

Melara, R. D., & Algom, D. (2003). Driven by information: A tectonic theory of Stroop effects. *Psychological Review, 110,* 422–471. http://dx.doi.org/10.1037/0033-295X.110.3.422

Melara, R. D., & Mounts, J. R. W. (1993). Selective attention to Stroop dimensions: Effects of baseline discriminability, response mode, and practice. *Memory & Cognition, 21,* 627–645. http://dx.doi.org/10.3758/BF03197195

Murphy, G. L. (2002). *The big book of concepts*. Cambridge, MA: MIT Press.

Nosofsky, R. M. (1986). Attention, similarity, and the identification-categorization relationship. *Journal of Experimental Psychology: General, 115,* 39–61. http://dx.doi.org/10.1037/0096-3445.115.1.39

Posner, M. I., & Snyder, C. R. R. (1975). Attention and cognitive control. In R. L. Solso (Ed.), *Information processing and cognition: The Loyola Symposium* (pp. 55–85). Hillsdale, NJ: Erlbaum.

Risko, E. F., Schmidt, J. R., & Besner, D. (2006). Filling a gap in the semantic gradient: Color associates and response set effects in the Stroop task. *Psychonomic Bulletin & Review, 13,* 310–315. http://dx.doi.org/10.3758/BF03193849

Roelofs, A. (2003). Goal-referenced selection of verbal action: Modeling attentional control in the Stroop task. *Psychological Review, 110,* 88–125. http://dx.doi.org/10.1037/0033-295X.110.1.88

Rosch, E. (1978). Principles of categorization. In E. Rosch & B. B. Lloyd (Eds.), *Cognition and categorization* (pp. 3–48). Hillsdale, NJ: Erlbaum.

Schmidt, J. R., & Besner, D. (2008). The Stroop effect: Why proportion congruent has nothing to do with congruency and everything to do with contingency. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 514–523. http://dx.doi.org/10.1037/0278-7393.34.3.514

Schouppe, N., Ridderinkhof, K. R., Verguts, T., & Notebaert, W. (2014). Context-specific control and context selection in conflict tasks. *Acta Psychologica, 146,* 63–66. http://dx.doi.org/10.1016/j.actpsy.2013.11.010

Shedden, J. M., Milliken, B., Watter, S., & Monteiro, S. (2013). Event-related potentials as brain correlates of item specific proportion congruent effects. *Consciousness and Cognition, 22,* 1442–1455. http://dx.doi.org/10.1016/j.concog.2013.10.002

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review, 84,* 127–190. http://dx.doi.org/10.1037/0033-295X.84.2.127

Sternberg, R. J., & Ben-Zeev, T. (2001). *Complex cognition: The psychology of human thought*. New York, NY: Oxford University Press.

Taylor, S. E., & Fiske, S. T. (1978). Salience, attention, and attribution: Top of the head phenomena. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 11, pp. 249–288). New York, NY: Academic Press. http://dx.doi.org/10.1016/S0065-2601(08)60009-X

Verguts, T., & Notebaert, W. (2008). Hebbian learning of cognitive control: Dealing with specific and nonspecific adaptation. *Psychological Review, 115,* 518–525. http://dx.doi.org/10.1037/0033-295X.115.2.518

Weidler, B. J., & Bugg, J. M. (2016). Transfer of location-specific control to untrained locations. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 69,* 2202–2217. http://dx.doi.org/10.1080/17470218.2015.1111396

Wisniewski, E. J. (2002). Concepts and categorization. In D. Medin (Ed.), *Stevens' handbook of experimental psychology* (3rd ed., Vol. 2, pp. 467–531). New York, NY: Wiley. http://dx.doi.org/10.1002/0471214426.pas0211

Yamauchi, T. (2005). Labeling bias and categorical induction: Generative aspects of category information. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 538–553. http://dx.doi.org/10.1037/0278-7393.31.3.538

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