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Stimulus Control: The Sought or Unsought Influence of the Objects We Tend To

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Does the mere presence of the things we have tended to influence our actions systematically, in ways that escape our awareness? For example, while entering a tool shed, does perceiving objects that we once tended to (e.g., tools, musical instruments) influence how we then execute a simple action (e.g., flicking the shed's light switch)? Ancient traditions (e.g., *feng shui*) and contemporary approaches to action production (e.g., *continuous flow* and *cascade* models) hypothesize that the answer is yes. Although relevant to several fields (e.g., motor cognition, social cognition), for various reasons this hypothesis cannot be tested by traditional choice-response time interference paradigms, which involve more complex processes than our tool shed scenario. Using new paradigms that resemble detection tasks, three studies demonstrated that 'very incidental' action-related distracters systematically interfere with simple, repeated actions that involve minimal response selection and decision-making processes. In Study 2, incidental musical notation interfered more with the simple actions of expert sight-readers than with the same actions of non-musicians. A similar pattern of effects was obtained with a fully experimental design. The implications for theories of action production, environmentally-driven automaticity, and social cognition are discussed.

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One of the fundamental questions of psychology is how the mere presence of things in the world can influence our actions in ways that escape our awareness (c.f., Bargh, 2001; Zajonc, 1965). This question is intimately related to two profound questions—what determines which actions one happens to perform next (see review in Morsella, 2009), and how does the immediate environment influence this selection process (cf., Wood, Quinn, & Kashy, 2002)? For instance, do the objects that happen to fall upon the eye while entering a tool shed or walking down a city street unconsciously influence how we act, think, and attend to things? For example, while entering a tool shed, does perceiving objects that we once tended to (e.g., tools, abandoned musical instruments) influence how we then execute a simple action (e.g., flicking the shed's light switch)? If so, how, and to what extent? Illuminating this issue is the main burden of the literature review below and of the three studies presented here. These studies build upon ancient and contemporary notions about the nature of the (sought or unsought) influence of the incidental objects that we once tended to.

According to the Chinese philosophy of *feng shui*, the stimuli that one has previously *tended to* (e.g., an abandoned guitar, forgotten teddy bear, or disorganized bookcase) do in some manner automatically activate attentional, motivational, and action-related processes. From this standpoint, the influence of such ambient stimuli is strong: When unsought, activations stemming from these stimuli can cause 'mental clutter,' 'distraction,' or 'mental disharmony,' thereby interfering with intended action. For this reason, it is recommended in the ancient tradition that work-related objects be out of view while one attempts to rest the mind (Kingston, 1999). Decades ago, the Behaviorists would have conceptualized such an influence as a form of 'stimulus control' (Skinner, 1953), in which environmental stimuli 'with a history'—that is, stimuli that once exerted an influence on the behavioral repertoire—function as *discriminative stimuli* that increase the likelihood of expressing some behaviors over others, through a form of environmentally-driven automaticity.

Today, much of these phenomena are explained in terms of *incidental behavioral priming*, in which supraliminal stimuli (i.e., stimuli that one *is* aware of) influence one systematically, but in ways that one is unaware of (see review in Morsella & Bargh, 2011). Contemporary incidental priming research demonstrates that incidental, environmental stimuli (e.g., business suits) can unconsciously influence the degree to which behavioral dispositions (e.g., competitiveness) are expressed (Carver, Ganellen, Froming, & Chambers, 1983; Kay, Wheeler, Bargh, & Ross, 2004). For example, when primed with (typically word) stimuli associated with the stereotypes of 'elderly' or 'library,' people walk slower and speak more quietly, respectively (Aarts & Dijksterhuis, 2003; Bargh, Chen, & Burrows, 1996). These effects have been found not only with verbal stimuli that are semantically related to the goal (as in many studies), but also with material objects. For example, backpacks and briefcases prime cooperation and competitiveness, respectively (Kay et al., 2004); candy bars prime tempting hedonic goals (Fishbach, Friedman, & Kruglanski, 2003); dollar bills prime greed (Vohs, Mead, & Goode, 2006); scents such as cleaning fluids prime cleanliness goals (Holland, Hendriks, & Aarts, 2005); sitting in a professor's chair primes social behaviors associated with power (Chen, Lee-Chai, & Bargh, 2002; Custers, Maas, Wildenbeest, & Aarts, 2008); control-related words prime the reduction of prejudice (Araya, Akrami, Ekehammar, & Hedlund, 2002); and the names of close relationship partners (e.g., mother, friend) prime the goals that those partners have for the individual as well as those goals the individual characteristically pursues when with the significant other (Fitzsimons & Bargh, 2003; Shah, 2003). Together, these findings have led to the view that there is an automatic *perception-behavior link* from perceptual processing to action planning (Dijksterhuis & Bargh, 2001).

In laboratory studies investigating the nuts and bolts of simple motor acts, non-focal stimuli (i.e., stimuli that one does not intend to respond to) certainly do interfere with an intended action, but only under certain circumstances. For example, in interference tasks such as the classic Eriksen flanker task (Eriksen & Eriksen, 1974), participants are first trained to press one button with one finger when presented with the letter 'S' or 'M' and to press another button with another finger when presented with the letters 'P' or 'H'. After training, participants are instructed to respond to targets that are surrounded (i.e., 'flanked') by distracters. For example, participants are instructed to respond to the letter presented in the center of an array (e.g., SSPSS, SSMSS, SSSSS, targets underscored) and to disregard the flanking letters (the distracters). There is a consensus that response time [RT] depends on the nature of the distracters: Greater RTs are found when the distracters are associated with responses that are different in nature from those associated with targets (*response interference* [e.g., SSPSS or MMPMM]) than when they are different in appearance but associated with the same or a similar response (*stimulus interference* [e.g., SSMSS]; Eriksen & Schultz, 1979). The strong and reliable effect of response interference, reflecting conflict at the response rather than stimulus identification level (van Veen, Cohen, Botvinick, Stenger, & Carter, 2001), suggests that flanking letters can activate response codes to some extent (Starreveld, Theeuwes, & Mortier, 2004; Treccani, Cubelli, Della Sala, &

Umiltá, 2009). (See reviews in Cohen and Shoup, 1997, and Sanders and Lamers, 2002.) Shortest RTs are found when the distracters are identical to the target (e.g., SSSSS; Eriksen & Schultz, 1979; van Veen et al., 2001).

Recent evidence examining the subjective aspects of all forms of flanker response interference corroborates this view (Morsella et al., 2009). Morsella et al. (2009) also examined the behavioral and subjective effects of additional flanker conditions, such as having the target appear alone with nothing flanking it or with 'novel' distracters (*weak response interference* [weak RI]) that had not been encountered during training (e.g., ++S++). The weak RI condition could be construed as falling between the SI and RI conditions with respect to the amount of response interference it generates. In this condition, distracters are not part of the current response set. Although no responses had been learned toward them in the laboratory, it is assumed that, as environmental stimuli, they still elicit action plans (e.g., exploratory behavior such as attending and orienting to them; Tinbergen, 1952). In short, the greater the difference between the actions associated with the targets and distracters, the greater the RTs and self-reported urges to make a mistake (Morsella et al., 2009).

In support of models inspired by how activation flows in the nervous system, such as *continuous flow* models (Eriksen & Schultz, 1979) and *cascade* models (McClelland, 1979; Morsella & Miozzo, 2002; Navarrete & Costa, 2004), in which activation cannot help but spread from perceptual to motor areas/tracts of the brain (Coles, Gratton, Bashore, Eriksen, & Donchin, 1985), psychophysiological research shows that, in such response-interference tasks, competition involves simultaneous activation of the brain areas associated with the target- and distracter-related responses (DeSoto, Fabiani, Geary, & Gratton, 2001). (See review of cascade and continuous flow models in Morsella, 2009.) Consistent with this standpoint, findings suggest that incidental artifacts (e.g., hammers) can automatically set us to physically interact with the world (Tucker & Ellis, 2004; see neuroimaging evidence in Grézes & Decety, 2002; Longcamp, Anton, Roth, & Velay, 2005). For example, perceiving a cylinder unconsciously potentiates one's tendency to perform a power grip (see review in Ellis, 2009). In addition, it has been shown that, in choice RT tasks, the mere presence of musical notation interferes systematically with the responses of musicians but not of non-musicians (Levine, Morsella, & Bargh, 2007; Stewart, Henson, Kampe, Walsh, Turner & Frith, 2004).

Limitations of Previous Findings

Despite the overwhelming evidence that, in traditional choice-RT tasks, distracters can influence behavior, such demonstrations cannot address whether similar effects are obtained in the tool shed and street scene scenarios mentioned above, as was learned by one of the authors (EM) during a lively conversation with a flanker researcher at a scientific conference. The author asked the researcher whether flanker-like research should lead one to believe that, in everyday life, when entering a tool shed, perception of the ambient objects that one had once tended to should lead to systematic attentional and action-related effects that then influence how one performs a simple action (e.g., flicking a switch). The researcher convinced the author that, with the data at hand at this stage of understanding, such a generalization cannot be made for the following four good reasons.

First and most important, (*1*) in natural scenes, seldom are choice-RTs involved: It is seldom the case that the object of action (the shed's light switch) is replaced on another occasion by another kind of object (e.g., a button or hammer). (*2*) As well, in traditional response-interference paradigms (e.g., Eriksen & Eriksen, 1974; Starreveld et al., 2004; Stroop, 1935), distracters are in extraordinarily close proximity to targets (e.g., a 5-letter stimulus array that can be foveated without effort), but in natural scenes, they are *very* incidental, and are generally not bundled together spatially with targets as found in flanker arrays (e.g., MMSMM). (*3*) As well, experimental targets (e.g., the letter *H* or an arrow) are generally from the same class of stimuli as distracters (e.g., other letters or arrows), but natural targets (e.g., the light switch) are usually different in nature from background stimuli (e.g., hammers and wrenches). (*4*) In addition, the actions associated with distracters in natural scenes may not have been learned or expressed for some time. Actions toward objects are learned over the course of a lifetime and a given action-related object may not elicit overt responses for some time, as in the case of a long-forgotten toy.

In short, there is no evidence supporting the claim that, during the course of a day, one is continuously activating attentional and action-related processes when confronted with the objects that one has tended to or that, more specifically, the ambient tools of a shed or objects comprising a city scene can systematically influence the expression of a simple, intended action. Thus, it remains an open question whether such phenomena indeed can be generalized to the real world situations mentioned above. This question has been raised before (cf., Morsella & Miozzo, 2002, p. 561), but it has never been addressed empirically, and generalizing from extant data is invalid and premature, for the many reasons mentioned above. In accord with the views of others (Neisser, 1976), we believe that the time has come to begin extending the basic phenomena documented in laboratory settings to address in a more valid fashion the phenomena in the real world mentioned in our research question.

Overview: The Very Incidental Distracter Paradigm

Using an 'incidental' variant of the traditional flanker paradigm, we first set out to determine whether the basic response interference effects that have been obtained in traditional laboratory paradigms are produced in circumstances a bit more representative of our tool shed and street scene scenarios. Specifically, in Study 1 we assessed whether incidental stimuli that were previously associated with a given action interfere with a simple, repeated and highly rehearsed target action (simple detection) that requires minimal strategic, decision-making processes and minimal response selection. Given the subtle nature of our manipulations, we expected to find small but unambiguous response interference effects.

The most important aspect of our new paradigm is that, in effect, it does not require response selection: Resembling the light switch scenario, the same response is issued in each trial of the entire test phase of the experiment (as described in detail below). The test session involved no 'catch trials,' in which a different response (or withholding the response) was required. As the test phase of the experiment unfolded, there was nothing that would lead the participant to believe that he or she would have to emit a response different from what had been emitted. Of course, we did not tell participants that the same response would always be required. Doing so could introduce a host of artifacts, such as participants not paying attention, closing their eyes, or performing the action prematurely. Short of telling participants that the same response would always be required, the task was designed to be in effect, not a choice-RT task, but a form of *detection task.* It should be clarified that this particular form of detection task is not a pure detection task, because participants are never told before the block of trials that the same response will always be required, for the reasons mentioned above. This limitation is not shared by the task in Study 2, in which, as explained below, participants know that there is only one possible response that can be emitted on each trial.

Inspired by the limitations of Study 1 and reasons 3 and 4 outlined above, in Study 2 we extended the paradigm by testing whether, in a manner similar to that of the tool shed scenario, the mere presence of musical notation would interfere more with the intended non-musical actions of expert sight-readers than with the same actions of non-musicians. In this quasi-experimental study, we initially considered evaluating whether professionals such as carpenters, mechanics, and engineers are affected by the mere presence of their tools, but found it too challenging to find an adequate control group, for the tools of these trades are well-known to nonprofessionals. Instead, we adopted a more simple, feasible, and informative approach—testing whether musical notation induces more interference-like effects for expert sight-readers than for non-musicians. With respect to automatic action, sight-readers are an excellent population to study because sight-reading is presumably one of the most automatic of skills, and all forms of sight-reading—whether for guitar, piano, or trumpet—involve the activation of motor effectors. In addition, we selected musicians because many studies have shown that their skills do transfer to other domains, such as those involving motor ability, auditory acuity, and perceptual acuity (Gilman & Underwood, 2003; Koelsch, Schroger & Tervaniemi, 1999; Levine et al., 2007; Ragert, Schmidt, Altenmuller & Dinse, 2004). Study 3 replicated this pattern of results but with a design that was fully experimental, thereby addressing the kinds of concerns raised by the quasi-experimental nature of Study 2. In addition, Study 3 included a condition that captures aspects of the standard flanker SI condition, thus testing whether more than just interference can be observed in our incidental distracter paradigm.

To summarize, the main goal of these new studies was to build on the automaticity and priming literature by assessing whether the general pattern of flanker-like interference effects are found in contexts that are a bit more representative of our tool shed scenario. Together, these findings demonstrate how, consistent with the ancient philosophy of feng shui, the mere presence of objects that one has tended to influence behavior systematically, in ways that one is not always aware of.

STUDY 1

Participants were trained to perform a simple action (to say “ba”) whenever they saw a circle in the center of the screen and to perform a very different action (press a button) whenever they saw a square in the same position. (We chose the vocalization “ba” because, as a bilabial stop, it is easily detected by microphone.) Apart from logistical considerations, we chose these two actions because they are distinct actions involving different effectors. After training, participants were instructed to respond only to the stimulus presented in the center of the screen (the target) and to disregard all other stimuli (the distracters). Sometimes the target was surrounded by squares, which were associated with the button-press response (forming the *response interference* [RI] condition), and sometimes by wavy lines, which were not associated with any actions (forming the *weak RI* condition, following Morsella et al., 2009). Again, although no responses had been learned in the laboratory toward the latter, it was assumed that, as environmental stimuli, they would still elicit some action plans (e.g., exploratory behavior such as attending and orienting to them). For the sake of comparison, a further condition consisted of presenting the circle alone, without any distracters (the *alone* condition). Our dependent measure was the RT to the target stimulus.

Control participants responded to the same test stimuli without having been trained to respond to squares. Instead, these controls participated in an otherwise identical, sham training session involving stimuli not presented during the test phase of the study (i.e., no squares were presented during their training). The control condition was necessary to rule out the possibility that, in this paradigm (the condition is unnecessary in standard flanker paradigms), interference results not from the activation of action plans, but from some other property of the stimuli (e.g., a perceptual or semantic property). We expected to find small but unambiguous interference effects from the RI condition, but only for trained participants.

METHOD

Participants. Forty Yale University students participated for class credit or $8.

Procedure. Experimental "trained" participants (n = 20) were run individually and instructed to say "ba" as soon as they saw a black circle (3 cm diameter) in the center of a white computer screen (43 cm, 60 Hz, viewing distance ≈ 48 cm) of an Apple eMac computer, and to press a button of a PsyScope button box (Model 2.02; New Micros; Dallas, TX) with the index finger of their left hand as soon as they saw a black square (3 x 3 cm). Vocal responses were detected by a microphone (Model 33-3014; Radio Shack; Fort Worth, TX) connected to the button box. The session began with a familiarization phase of 10 practice trials in which an equal number of circle and square stimuli appeared in random order. Participants found the task to be nearly effortless. Stimulus presentation and data recording were controlled by the PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). The subsequent two studies used the same hardware and presented stimuli in a similar manner (e.g., upon a white background).

A familiarization trial went as follows. Two beeps alerted the participant about the beginning of the trial. (In this kind of experiment, it is customary for participants to indicate their readiness by pressing a button, but we did not use this method because we were concerned that such an action would contaminate our button-pressing measure.) After 1700 ms, a fixation point (+) was shown at the center of the screen for 2000 ms. It was then replaced by either a circle or square, which remained on the screen until the participant responded. Participants were instructed to respond as quickly and as accurately as possible.

After the familiarization phase and a short break, participants responded to two blocks of training trials. Each block consisted of 50 consecutive trials displaying the same stimulus (e.g., a block of 50 squares followed by one of 50 circles). The order of presentation of these blocks was counterbalanced across participants. Then, after another short break, participants responded to 50 trials in which square and circle trials appeared an equal number of times in random order. The training procedure for control participants (n = 20) was identical except that participants were trained to button-press for an object resembling a lightning bolt (occupying about 6 sq cm), and squares were never presented.

After training, participants were told that the remainder of the study (consisting of 90 trials) would involve the same task and that they should continue to respond to the object in the center of the screen (the target), though now they must also disregard whatever stimuli appear peripherally (the distracters). In 30 of the 90 trials, the circle appeared alone; in 51 of the trials, the circle was flanked by wavy lines (weak RI condition); and in 9 of the trials, the circle was surrounded by squares (RI condition; Figure 1). We presented the RI stimuli in only 10% of the trials because we were concerned that participants would habituate to them if they appeared more often, as occurred in piloting (n = 10). In this and in the following two studies, distracter stimuli were presented surrounding the target in the center of screen, occupying a region less than 12 cm in diameter, so that stimuli would fit well within the participant's visual field (see Bargh & Chartrand, 2000) but could not be foveated as easily as the entire stimulus array in the classic flanker. Participants were reminded to respond as quickly and as accurately as possible and to avoid anticipations. To diminish possible demand characteristics and to keep them attentive throughout the test phase, participants remained uninformed that the same behavior (saying "ba") would be elicited on each trial.

Data Collection and Analysis. After Woodworth and Schlosberg (1954) and Morsella et al. (2009), RTs below 200 ms and above 2 s were excluded from analysis, resulting in the loss of 0.4% of the data set. This trimming procedure was done for all the RT analyses of all the subsequent studies. Responses were analyzed in a 2x3 mixed design ANOVA, in which training (trained versus control) was a between-subjects factor, and environment (alone, RI, or weak RI) was a within-subjects factor.

RESULTS AND DISCUSSION

Mean RT across all conditions was 416.34 ms (*SEM* = 9.36). There was a main effect of environment, $F\ (2, 76) = 40.478$, $p < .0001$ ($\eta_p^2 = .52$) and no main effect of training, $F\ (1, 38) = .008$, $p = .93$ ($\eta_p^2 < .001$). Importantly, there was a significant interaction between training and environment, $F\ (2, 76) = 3.638$, $p = .03$ ($\eta_p^2 = .09$), in which trained participants showed greater interference in the RI condition (Figure 2).

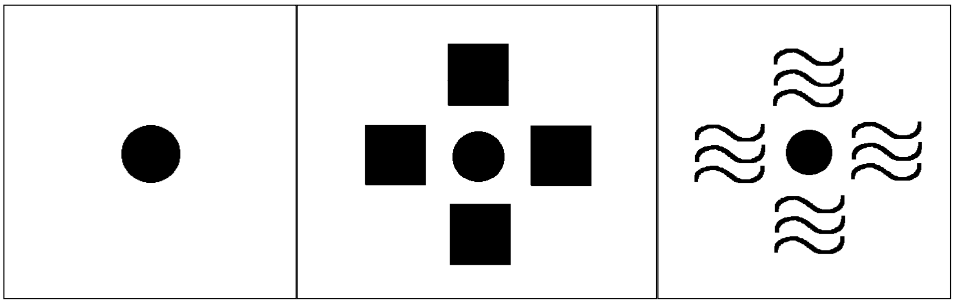

Figure 1: Distracter environments of Study 1: alone, response interference (squares), and weak response interference (wavy lines) environments. Not drawn to scale.

In summary, even with circumstances more representative of our tool shed scenario, the mere presence of action-related stimuli interfered with the performance of a simple, intended action involving minimal response selection. This finding replicates what has been found in choice-RT tasks that involve processes and actions that are appreciably more difficult and distracters that are less incidental.

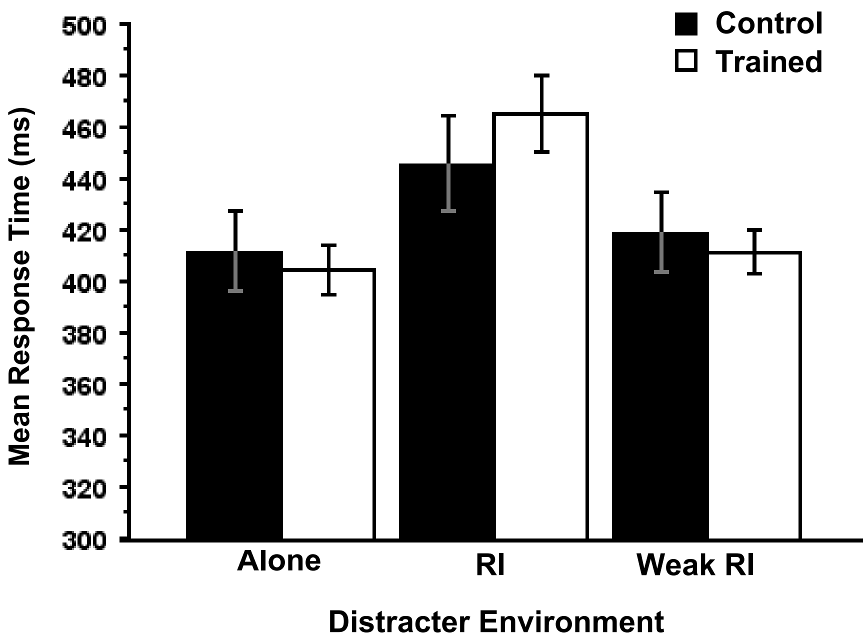

Figure 2: Mean vocal response time (ms) as a function of training (trained versus control) and environment (alone, response interference [squares], or weak response interference). Error bars signify ± SEM.

STUDY 2

To address the questions inspired by reasons 3 and 4, a study would have to demonstrate interference from objects that are very different from targets and are associated with actions learned outside of the laboratory and learned over a substantial period of time. It would also demonstrate interference from objects that have not elicited responses for some time, at least not moments before the test phase of an experiment. As in our previous study, participants in this study learned to say "ba" as quickly as possible to a circle presented in the center of the screen. Unlike in Study 1, in this purer detection task, each participant knew that only one possible response could be emitted on each trial. On some trials, however, the circle was surrounded by musical notation (the distracters). Our goal was to determine whether the musical notation produces greater interference for sight-readers than for controls.

METHOD

Participants. Twenty-nine Yale University students (18 sight-readers, 11 non-sight-readers) participated for class credit or $8.

Procedure. The procedure was the same as that of Study 1, except that there was no familiarization phase, and all participants were trained to respond only to the circle stimulus, saying “ba” for 100 trials during training. After the training session and a short break, participants were instructed to respond only to the object in the center of the screen and to disregard anything else that may appear on the screen. They were presented with 90 trials in which a circle appeared as a target in the center of the screen. In 81 of the trials, the circle appeared alone, and in only 9 (10%) of the trials, the circle was flanked by four identical images of common musical notation (a series of major chords; the staffs were 6.1 cm wide x 1 cm high), as shown in Figure 3. Again, having participants perform the same response throughout the test phase was meant to minimize artifacts from cognitive load, confusion, or from any decision-making, strategic processes, such as those that might occur in traditional flanker tasks.

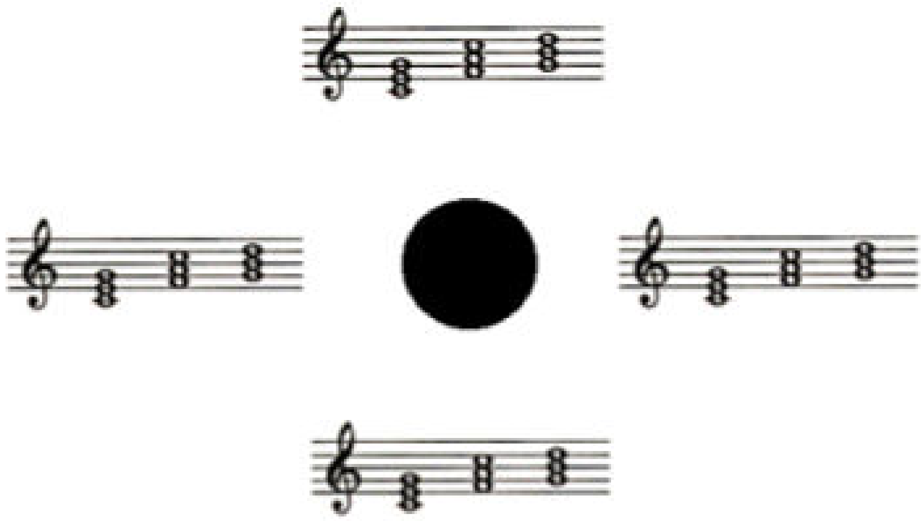

Figure 3: Musical notation environment of Study 2. Not drawn to scale.

To diminish the potential for experimental demand, we determined whether a participant belonged to the sight-reader (n = 18) or non-sight-reader group (n = 11) at the end of the experimental session. In a verbal funnel debriefing (based on Levine et al., 2007), participants were asked the following questions: Have you ever received any formal musical training? Have you ever been capable of reading musical notation without much effort? Would you consider yourself an expert sight-reader? Based on the answers to these questions, two judges determined the group to which a given participant was assigned. Judges reached a consensus regarding all of the assignments. It should be noted that although true expertise requires ten years of training (Ericsson & Lehmann, 1996), because our participant pool was fairly young (age range was 18 to 21), we deemed a musician to be an expert if he or she trained for at least six years.

RESULTS AND DISCUSSION

Trimming resulted in the loss of 3.6% of the data set. Responses were analyzed in a 2x2 mixed design ANOVA, in which sight-reading training (trained versus untrained) was a between-subjects factor, and distracter environment (musical notation versus none) was a within-subjects factor. Mean RT across all conditions was 359.94 ms (*SEM* = 11.98). There was a main effect of environment, F (1, 27) = 52.85, $p < .0001$ ($\eta_p^2 = .66$) and no main effect of training, F (1, 27) = 1.59, $p > .10$ ($\eta_p^2 < .06$), but, importantly, there was a significant interaction between training and environment, F (1, 27) = 5.55, $p = .026$ ($\eta_p^2 = .17$), in which musical notation produced greater interference in sight-readers than in non-sight-readers. In addition, planned comparisons revealed a trend in which, when setting the inter-group differences in general responding between musicians and controls aside, musical notation still tended to elicit larger interference in musicians than controls, t (27) = 1.715, $p = .0978$. Figure 4 reveals which additional contrasts between the four cells were significantly different from each other (ps < .05).

Control of critical variables is by definition limited in such a quasi-experimental study. Clearly we were unable to control the nature and amount of musical training in our sight-reading participants. Moreover, as with the classic flanker, with this paradigm one cannot ascertain that the interference reflects just the activation of unconscious action plans (cf., Treccani et al., 2009). Beyond their capacity to elicit action plans, musical stimuli are special stimuli for musicians for multiple reasons. It is reasonable to assume that these stimuli activate more attentional and semantic processes in experts than in non-experts. These factors alone may well be enough to produce an artifactual effect. Nevertheless, the predicted pattern of interference was found.

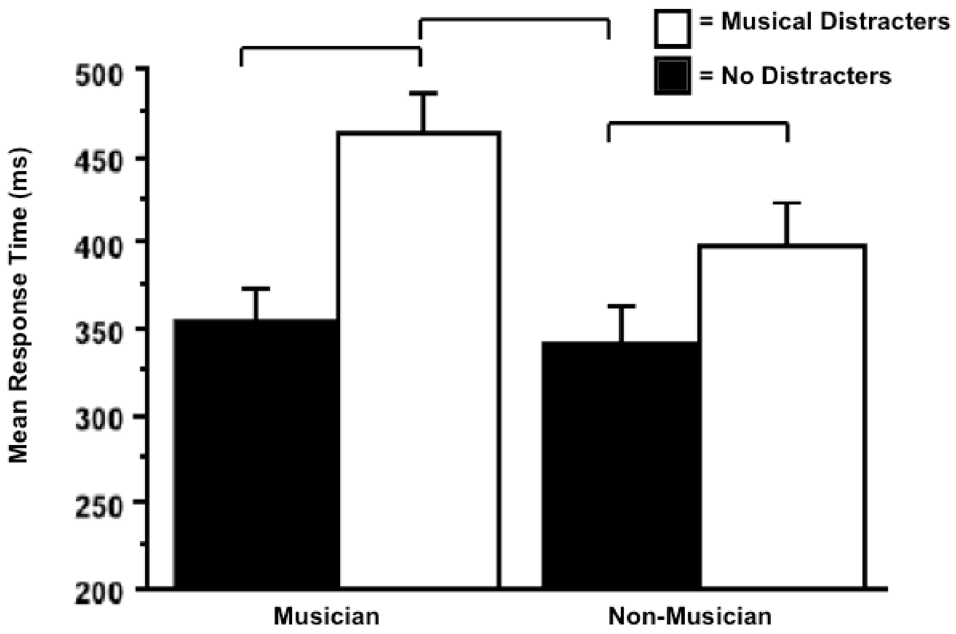

Figure 4: Mean vocal response time (ms) as a function of training (musician versus non-musician control) and environment (alone, music distracters). Error bars signify ± SEM. Horizontal lines signify significant contrasts (ps < .05).

Our finding provides further evidence that incidental, action-related objects can interfere with the execution of a simple, well-rehearsed intended action that does not require decision making. Interference was found even though distracters were very incidental and unrelated to targets, targets and distracters never occupied the same regions of the sensorium, participants never responded to distracters, the actions associated with distracters were not in the response set, and the actions associated with distracters had been learned some time ago and in a different setting.

STUDY 3

Response Interference versus Stimulus Interference

While demonstrating flanker-like effects under conditions that more closely resemble our tool shed scenario, the findings of Studies 1 and 2 are limited in that they are showing only one kind of flanker-like effect, namely, interference. Following previous research (Eriksen & Schultz, 1979; Shallice, 1972; Treccani et al., 2009; van Veen, et al., 2001), continuous flow and cascade approaches predict that interference will be greatest when distracters recruit responses different from those of intended action. For this reason the action tendencies associated with distracters and with targets (saying "ba") in Studies 1 and (most likely) Study 2 involved very different effectors and responses. In the real world, however, it may be the case that a target (e.g., a can of soda) and distracter (e.g., wine bottles) lead to similar actions. Hence, Study 3 assessed the effects of distracters that recruit a similar response using the same effector region. In a modified version of Studies 1 and 2, in addition to being trained to say "ba" when presented with circles and to press a button when presented with squares, participants in this study learned to blow into a microphone when confronted with a triangle. Thus, in some cases, the distracters (triangles) and targets (circles) activated similar action plans using effectors of the mouth region. According to previous flanker research (Ericksen & Schultz, 1979; Morsella et al., 2009; van Veen et al., 2001), triangles (the similar response condition) should lead to less interference than the RI condition. To capture aspects of the phenomenon in Study 1 and 2, we retained hand and mouth effectors in this fully experimental study.

In addition, in this extension and replication of Studies 1 and 2, we also took the opportunity to test some corollary hypotheses of this approach. Does the quantity of distracters (4 versus 8) moderate the magnitude of the interference effect? Perhaps a greater number of distracters increases their influence. Second, we tested whether surrounding the target circle with other circles can facilitate the target response. However, data from traditional response conflict paradigms such as the flanker task suggest that, as a product of repetition priming, such facilitation can occur only if the 'boosting stimuli' precede the targets by some time (e.g., 200 ms; cf., Flowers, 1990; Posner, 1978; Sanders & Lamers, 2002). Thus, there is evidence against the notion that, when flicking a light switch, the simultaneous and incidental presence of other switches will facilitate the response. We took the opportunity to address the issue using the incidental distracter paradigm. Our primary new prediction for Study 3 was that the same pattern of RI and SI effects obtained in choice-response time tasks are evident in our incidental version of the flanker, which includes minimal response selection.

METHOD

Participants. Fifty-seven Yale University students participated for class credit or $8.

Procedure. The procedure was the same as that of Study 1, except that participants (*n* = 29) were also trained to blow into the microphone whenever they saw a triangle (3.1 cm high and 3.3 cm at the base). The training session began with a familiarization phase of 10 trials in which squares, triangles, and circles were presented in random order. After a short break, participants responded to 3 blocks of training trials; each block presented the same stimulus for 50 consecutive trials. The order of presentation of these blocks was counterbalanced across subjects. After another short break, participants responded to 50 trials in which square, circle, and triangle trials appeared in random order. The training procedure for control participants (*n* = 28) was identical to that of experimental participants except that squares and triangles were never presented. Instead, participants were trained to button-press for a plus sign (occupying about 6 sq cm) and to blow for an equally-sized object resembling a lightning bolt. As in Study 1, the test phase was identical for control and experimental participants. Each of the 80 trials presented a circle in the center of one of five randomly selected distracter environments: identical (circle distracters), RI (square distracters), similar response (triangle distracters), and weak RI (wavy lines). We took the opportunity to have a mixed (squares and triangles) condition. Each kind of environment appeared 16 times, with 4 or 8 distracters, forming the high versus low magnitude conditions. All stimulus environments are presented in Figure 5.

Data Collection and Analysis. Trimming resulted in the loss of 0.5% of the data set. The data from one sleepy participant who produced exceedingly long RTs (the only participant whose mean RT was more than 3 *SD*s above the group mean) were excluded from the analysis. Responses were analyzed in a 2x2x5 mixed design ANOVA, in which training (trained versus control) was a between-subjects factor, and magnitude (high versus low) and environment (identical, RI, similar response, mixed, and weak) were within-subjects factors. In this and the subsequent studies, because the same response was elicited over and over, no errors were made in response selection.

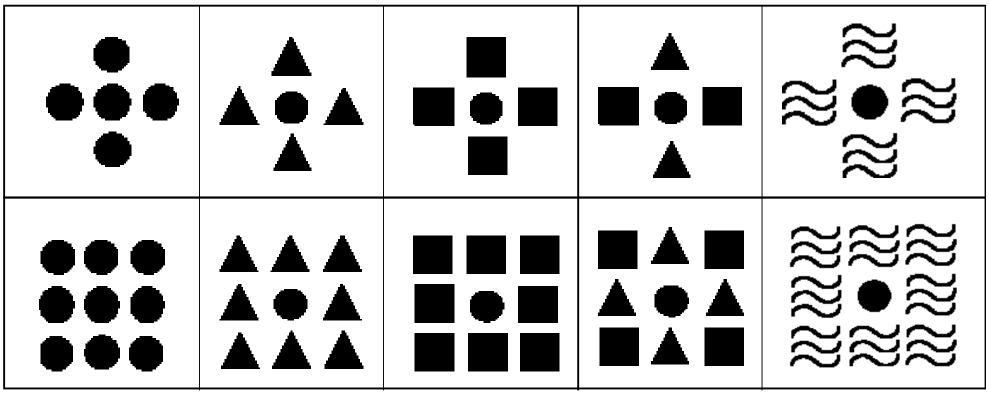

Figure 5: Stimulus environments of Study 3, with low magnitude conditions in the top row and high magnitude conditions in the bottom row: boost (circles), similar response (triangles), response interference (squares), mixed, and weak RI (wavy lines) environments. Not drawn to scale.

RESULTS AND DISCUSSION

Mean RT across all conditions was 430.59 ms (*SEM* = 9.81). There was no main effect of environment, F (4, 216) = 1.530, p = .195 (η_p^2 = .03), no main effect of training, F (1, 54) = .134, p = .716 (η_p^2 < .01), no main effect of magnitude, F (1, 54) = 2.197, p = .144 (η_p^2 = .04), and no interaction between magnitude and environment, F (4, 216) = .902, p = .464 (η_p^2 < .02). In short, the pattern of data was the same for high and low magnitude environments. The descriptive statistics are presented in Table 1. For the sake of clarity, Figure 6 shows the data with high and low magnitudes combined.

Importantly, replicating Study 1, there was a significant interaction between training and environment, F (4, 216) = 2.751, p = .029 (η_p^2 = .05). Collapsing magnitude reveals the same training by environment interaction, F (4, 216) = 2.786, p = .028 (η_p^2 = .05). There was no such interference for the similar response (triangles) or mixed conditions. A mixed ANOVA with just the conditions of Study 1 (low magnitude RI and weak RI conditions) replicates the interaction between training and environment found in that study, F (1, 54) = 4.069, p < .05.

Table 1.

Environment and Magnitude	Response Times Trained Participants Mean	SEM	Control Participants Mean	SEM
Identical				
Low	432.73	17.99	419.36	13.30
High	438.24	16.09	419.26	15.18
Response Interference (RI)				
Low	442.02	20.26	410.98	11.01
High	449.49	19.76	425.37	13.55
Similar Response (SR)				
Low	426.43	13.56	428.76	16.50
High	421.22	15.97	423.65	14.99
Mixed Distracters (RI and SR)				
Low	417.98	15.10	425.91	12.90
High	437.83	20.76	431.94	15.04
Weak Response Interference				
Low	431.17	17.03	434.08	15.42
High	441.62	15.86	446.85	17.25

Although the pattern of results resembles what was predicted and found in standard forms of the flanker, with the conditions for RI and Similar Response yielding distinct patterns of results among trained and control participants, one can draw only very few conclusions from such a subtle manipulation having so few RI trials. For example, with such low statistical power, planned comparisons revealed that, within either the trained or control groups, significant differences were found only in the control group, between the RI and Weak RI conditions, t (26) = -3.039, $p <$ .05 and identical and weak conditions, t (26) = -3.054, $p < .05$. The effect of Weak RI condition for the control group may reflect the fact that the wavy lines were more distracting than the other shapes, because the wavy lines are not geometrical figures. The same effect might have been found in the trained group, but the effect was counteracted by response interference. Future research will have to address this issue. It is important to note that interference from distracters that are not related to any actions learned in the laboratory affected performance most in Study 2, when musical notation interfered with the actions of musicians. For several reasons, these distracters are quite different from the wavy line stimuli constituting the weak RI conditions of this study. For example, it is more likely for a musically-trained participant to have specific actions associated to the notation than for an average participant to have actional dispositional toward the wavy lines, which may nonetheless influence attentional processing.

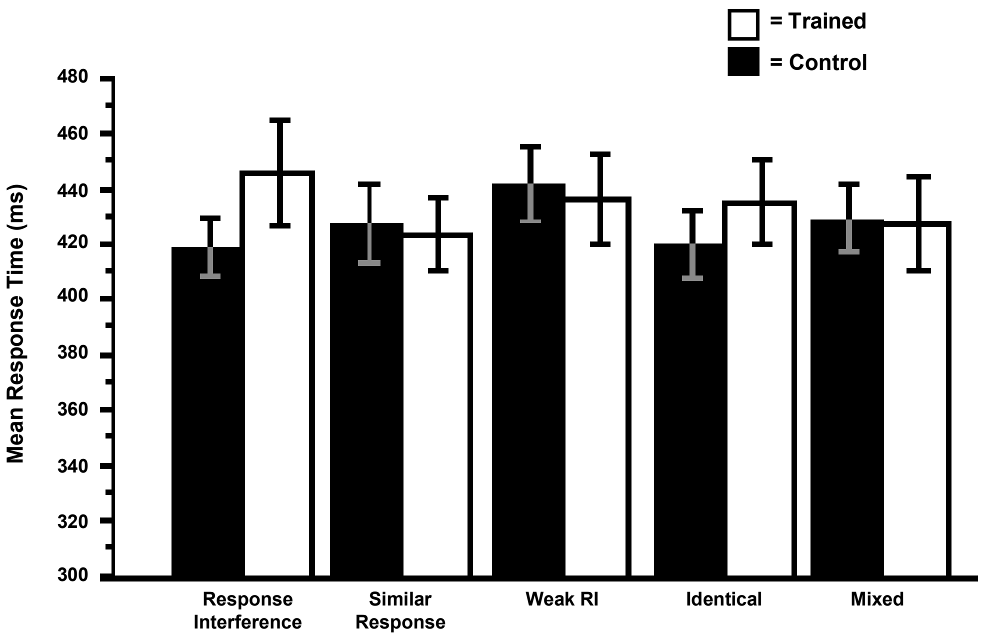

Figure 6: : Mean vocal response time (ms) as a function of training (trained versus control) and distracter environment. Error bars signify ± SEM.

Mirroring previous findings from less incidental paradigms (Flowers, 1990; Posner, 1978), the identical condition did not facilitate responses. Thus, it seems that, when flicking a switch, the simultaneous and incidental presence of other switches will have little or no effect. The findings suggest that the presence of triangles did not interfere with the performance of experimental participants; this was expected because blowing and saying "ba" involve a similar activation of the same effector region. Together, the data replicate the finding that, for notable interference, elicitors must recruit a response different from that of intended action, which is consistent with choice RT flanker paradigms (Ericksen & Schultz, 1979; van Veen et al., 2001). More specifically, this lack of interference is consistent with results from picture-picture object naming paradigms (Morsella & Miozzo, 2002; Navarrete & Costa, 2004), in which there is no interference when the distracter and target picture elicit a similar response (e.g., when a bed was paired with a bell).

In addition, because the interference effect appears to depend upon the actual nature of the competing plans, the present data suggest that the results of Study 1 were not simply due to indecision regarding which response to produce in the presence of square distracters. Such indecision would presumably occur in the similar response (triangle) condition as well, yet no such effect was found. Note also, however, that we did not find that having four versus eight distracters moderates the size of the interaction effect or that facilitation occurs when distracters match the target (the identical condition). As always, caution is in order when drawing conclusions from such null findings, especially when the findings stem from a paradigm that, because of methodological concerns (e.g., habituation to the RI condition, as revealed in piloting), has low statistical power. Nevertheless, together with findings from less incidental stimuli (Eriksen & Schultz, 1979; Shallice, 1972; van Veen, et al., 2001), these data corroborate the notion that the nature of the motoric response is critical for interference effects, both in the laboratory and in everyday scenarios (cf., Treccani et al., 2009).

GENERAL DISCUSSION

Can the mere presence of the things that we have once tended to systematically influence our current, intended actions? According to ancient traditions and the current literatures on incidental priming, on environmentally-driven automaticity, and on response interference paradigms, the answer seems to be yes. The goal of this project was to demonstrate that the objects we tend to can influence our everyday actions in a manner similar to what is found in laboratory paradigms.

Simulating our tool shed scenario, in Study 1 we found that, regardless of an actor's intentions, the very incidental presence of action-related objects interfered with the execution of a simple, well-rehearsed action that required minimal strategic or decision-making processes. In Study 2, we further mimicked our tool shed scenario and demonstrated that, in a detection task that is purer than that of Study 1, the very incidental presence of work/trade-related objects interfered with the execution of the same simple action: Musical notation interfered more with the actions of expert sight-readers than of non-musicians. Study 3 found similar effects with an experimental design, including a condition capturing aspects of the standard stimulus interference condition. Apart from replicating in our incidental paradigm the response interference effect found in laboratory studies, the results of Study 3 also reveal that the effects of Study 1 were not simply due to indecision regarding which response to produce in the presence of square distracters.

In all three studies, the manipulation was subtle enough to rule out the possibility that our effects resulted from confusing participants or from leading them to commit higher-level, strategic errors (a problem with the classic flanker paradigm; Eriksen & Schultz, 1979). Unlike in traditional response interference tasks, the same simple response was required on each trial, resembling the demands of the 'light-switch' action in our tool shed example. It is important to reiterate that, for the first time, in Study 2 interference was found even though (1) distracters were very incidental and unrelated to targets, (2) targets and distracters never occupied the same, exact regions of the sensorium, (3) participants never responded to distracters, (4) the actions associated with distracters were not in the response set and had been learned in a different context. Most important, and despite the small size of the effects, it is quite surprising that such effects can be detectable in paradigm that, in effect, is a form of detection task. With these data, one can conclude that, as predicted by ancient traditions (e.g., *feng shui*), the objects one has tended to may have unsought influences, but perhaps only under particular circumstances, such as those resembling RI but not SI conditions.

The current project is limited in several ways. The studies were not designed to disambiguate whether the effects were primarily caused by the automatic activation of attentional processes or of actional processes, phenomena that are intimately (if not inextricably) related (Rizzolatti, Riggio, Dascola, & Umiltá, 1987). In addition, though attempting to capture the tool shed scenario, our paradigm differed from this natural setting in various ways. First, unlike the tool shed scenario, our paradigm involved multiple trials, and the stimuli surrounding the target varied over time. In our paradigms, RI effects occurred when there was a very low proportion of instances in which flankers elicited a different response. In the tool shed scenario, flanker type does not vary so often. Study 1 is also different from our tool shed scenario in another way. The task is actually more analogous to entering the shed and always finding the light switch in the same place (and always producing the same response to it) but keeping in mind that, one day, a different object may be in its place. Such an arrangement is unlikely to occur in everyday life. A better everyday analogy for Study 1 would be the following example provided by an anonymous editorial reviewer. Imagine that one customarily keeps the house keys on a key ring right next to the door. As one leaves the house, one always reaches for the keys. On one day, however, another person takes the keys by mistake or replaces the keys with another set of keys. Henceforth, one will anticipate that the keys will tend to be there, but that, perchance, they might not be there every so often. Of course, this is not an issue in Study 2, in which participants knew that the same response would be elicited on each trial.

Another limitation of the current approach is that, for Study 2, all musicians were grouped together regardless of the particulars of their instrument of choice, even though different kinds of musicians may possess distinct action modes. For example, it is unclear how activation of an expertise-based action mode may cause differential performance in a participant who plays one versus another specific instrument.

More profoundly, to those who are not connoisseurs of the flanker task, Studies 1 through 3 may be seen 'nothing new,' that is, as just another replication of the classic paradigm. To some extent, we welcome this criticism because the first three studies were designed, not to arrive at a startling, ground-breaking findings whose effects require replication, but to corroborate that the general pattern of effects obtained from flanker paradigms occurs under circumstances more representative of those of everyday action. Those who view the standard flanker task as an invalid paradigm with which to answer our tool shed scenario question would welcome this result as an important addition to the response interference literature. It is important to reiterate that it is quite remarkable that any effects (RI- or SI-like) can be observed in a paradigm resembling a simple detection task.

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