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Motormouth: Mere Exposure Depends on Stimulus-Specific Motor Simulations

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The authors apply an embodied account to mere exposure, arguing that through the repeated exposure of a particular stimulus, motor responses specifically associated to that stimulus are repeatedly simulated, thus trained, and become increasingly fluent. This increased fluency drives preferences for repeated stimuli. This hypothesis was tested by blocking stimulus-specific motor simulations during repeated exposure. In Experiment 1, chewing gum while evaluating stimuli destroyed mere exposure effects (MEEs) for words but not for visual characters. However, concurrently kneading a ball left both MEEs unaffected. In Experiment 2, concurrently whispering an unrelated word destroyed MEEs for words but not for characters, even when implemented either exclusively during the initial presentation or during the test phase and when the first presentation involved an evaluation or a mere study of the stimuli. In Experiment 3, a double dissociation between 2 classes of stimuli was demonstrated, namely, words (oral) and tunes (vocal). A concurrent oral task (tongue movements) destroyed MEEs for words but not for tone sequences. A concurrent vocal task (humming "mm-hm") destroyed MEEs for tone sequences but not for words.

Keywords: embodiment, mere exposure, fluency, evaluative judgments, voice

> Lo-lee-ta: The tip of the tongue taking a trip of three steps down the palate to tap, at three, on the teeth. Lo. Lee. Ta.
>
> —Vladimir Nabokov

One of the most established facts of modern psychology is the finding that stimuli that are repeatedly encountered are increasingly liked—the well-known *mere exposure effect* (Zajonc, 1968; for a review, see Bornstein, 1989). In general, this effect is explained by the concept of processing fluency, which is the content-independent speed and easiness of processing a stimulus (Bornstein & D'Agostino, 1992; Phaf & Rotteveel, 2005; Reber, Winkielman, & Schwarz, 1998; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). More specifically, it has been argued that stimuli are processed more fluently and faster when they are repeatedly processed (Jacoby & Dallas, 1981; Jacoby, Kelley, & Dywan, 1989; Jacoby & Whitehouse, 1989). Because increased fluency per se automatically triggers positive affect (e.g., Harmon-Jones & Allen, 2001; Reber et al., 1998; Topolinski, Likowski, Weyers, & Strack, in press; Winkielman & Cacioppo, 2001), it has been argued that this fluency-triggered positive affect changes the evaluations of repeated stimuli toward increased preference (e.g., Phaf & Rotteveel, 2005; Reber et al., 2004).

However, the processing of stimuli involves mostly multiple processes that often run in parallel (see, e.g., Borowsky & Besner, 2006, for visual word recognition). In the case of the mere exposure of words (e.g., Stang, 1975), for example, fluency gains may stem from processing the visual properties of the word, the lexical identification, or covertly pronouncing the word while reading. Therefore, the exact processes that exhibit fluency gains still need to be identified.

We adopt an embodied perspective on mere exposure to localize the sources of fluency gains for repeated stimuli. According to the embodiment literature (e.g., Niedenthal, 2007), individuals represent stimuli by covertly simulating the sensorimotor processes that run when the stimuli are perceived or acted on (e.g., Barsalou, 1999; Wilson, 2002). That is, the specific motor responses that are associated with a particular stimulus are assumed to be automatically simulated if the stimulus is encountered. For example, passive viewing of graspable objects triggers neuronal activity in the motor and parietal areas that are responsible for actually grasping these objects (Chao & Martin, 2000; Tucker & Ellis, 1998). Similarly, retrieving a kanji character from memory triggers motor system activity in areas that are associated with actually writing kanji characters (Kato et al., 1999). Finally, in skilled typists, the perception of letters automatically triggers the motor programs that are executed in typing those letters (Beilock & Holt, 2007; Van den Bergh, Vrana, & Eelen, 1990). Even the imagination of actions, or external events that are yet to occur, triggers specific motor simulations reenacting previous experiences with these events (e.g., Schubotz, 2007; Schubotz & von Cramon, 2004).

The fluency with which these covert sensorimotor simulations run can actually shape preference judgment, which was most recently shown by the impressive work of Beilock and Holt (2007). Specifically, they presented dyads consisting of letters that were either typed with the same finger using traditional typing

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methods (implying interfering motor responses) or typed with different fingers (implying noninterfering motor responses). Replicating Van den Bergh et al. (1990), Beilock and Holt (2007) found a preference in skilled typists for letter dyads that consisted of letters that are typed with different fingers, obviously because these dyads, if typed, produce the least motor interference. Most important, these preferences vanished when participants held a motor plan in memory that involved the fingers that would be used to type the presented letter dyads. The authors convincingly argued that covert sensorimotor simulations of typing the presented dyads drove those preference judgments because less motor interference between the responses for two letters led to increased fluency of covert motor simulation and triggered positive affect, which then resulted in a preference for the fluent dyads.

We adopt a similar embodiment account for the domain of mere exposure. We argue that through repeated exposure of a particular stimulus, its specific motor response is repeatedly simulated, thus trained, and runs with increasing fluency. We argue that this increased motor fluency is the actual cause for preference for the repeated stimuli. To demonstrate our argument, we wanted to block simulations in stimulus-specific motor systems to show that mere exposure effects vanish for stimuli that are associated with the blocked motor system, whereas mere exposure effects remain stable for stimuli that are not associated with the blocked motor system. Take, for example, two classical stimulus types from mere exposure research, namely, nonsense words (e.g., Stang, 1975) and tone sequences (e.g., Heingartner & Hall, 1974; Peretz, Gaudreau, & Bonnel, 1998; W. R. Wilson, 1979). Words are to be spoken; melodies are to be sung. Following from our account, mere exposure for words may be driven by motor simulations in the effectors that are responsible for pronouncing words (namely, the oral muscles), whereas mere exposure for melodies may be driven by the effectors that are responsible for singing melodies (namely, the vocal folds). Consequently, blocking oral muscles should impair mere exposure effects selectively for words (Experiments 1 and 2), whereas blocking vocal muscles should impair mere exposure effects selectively for melodies (Experiment 3). In the following, we outline our account more specifically.

Mere Exposure of Words and Motor Simulations in the Mouth

We argue that the mere exposure of a word automatically triggers oral motor simulations that are involved in pronouncing this word, because being exposed to words automatically triggers the overlearned response to read them (Stroop, 1935; for a review, see MacLeod, 1991). In the well-known Stroop task, for instance, the automatic response to pronounce a word interferes with the task to name the color in which the given word is printed. Furthermore, we argue that repeated exposure of the same word trains this oral motor simulation, rendering the covert pronouncing more fluent. This assumption is supported by two independent results in the literature. First, overt pronouncing of a word becomes more fluent with repeated exposure of the given word (e.g., Forster & Davis, 1984; Savage, Bradley, & Forster, 1990; Scarborough, Cortese, & Scarborough, 1977). Second, covert pronouncing also increases in fluency with repeated exposure, because the Stroop interference can be reduced by training the pronunciation of the presented words, thus rendering the covert pronouncing more efficient and less likely to interfere with naming the color (e.g., Ehri & Wilce, 1979; for a review, see MacLeod, 1991). Finally, we argue that it is this increased fluency of the motor simulation to pronounce the word that triggers positive affect and drives preferences for repeated words.

An empirical test of these assumptions would need to investigate the mere exposure of words when oral motor simulations are blocked. The central effectors in pronouncing words are the oral muscles (e.g., Inoue, Ono, Honda, & Kurabayashid, 2007). They can be blocked by an articulatory suppression (e.g., Cinan & Tanör, 2002; Emerson & Miyake, 2003; Saeki & Saito, 2004), for example, by concurrently pronouncing a task-irrelevant word (e.g., Miyake, Emerson, Padilla, & Ahn, 2004) or by simply chewing gum (e.g., Campbell, Rosen, Solis-Macias, & White, 1991). In Experiments 1 and 2, these articulatory suppression methods were used to investigate their impact on the mere exposure of words and visual characters.

Experiment 1

This experiment should initially establish an embodied account of mere exposure by blocking individuals' oral motor simulations while perceiving nonsense words. Regarding the mere exposure of verbal stimuli, at least two sources of fluency can be considered, namely, perceptual fluency (stemming from visually processing the word; e.g., Reber, Wurtz, & Zimmermann, 2004) and motor fluency (stemming from covertly simulating the pronunciation of the word; cf. Destrebecqz & Cleeremans, 2001; Shanks & Johnstone, 1999). Although the degree to which the two sources contribute to mere exposure effects is yet unexplored, it is plausible that motor fluency may play a greater role if the visual appearance of the word stimulus changes from the first to the second exposure, for example, because of a change in the font in which the word is typed. Thus, we hypothesized that blocking oral motor simulations would corrupt mere exposure selectively for visually changing words, because individuals cannot draw on any other cue than the fluency of the oral motor simulation. In the case of words that maintain their physical appearance from the first to the second exposure, we expected individuals to switch from the motor fluency to perceptual fluency as a source for their evaluative judgment—hence still exhibiting mere exposure effects. As a control condition, we used a secondary motor task for the hand, which we expected would not interfere with any mere exposure effects, because the processing neither of words nor of visual characters is specifically connected to manual muscles. As control stimuli, we used nonverbal visual characters, for which we expected mere exposure effects to be unaffected by any motor task.

Method

Participants. Sixty (40 women, 20 men) right-handed nonpsychology students participated for a small candy gift as compensation.

Materials. Twenty Chinese ideographs served as visual characters (cf. Murphy & Zajonc, 1993), and 40 ancient Greek words served as nonsense words (e.g., *NEPHELOKOKKYGIA* meaning cloud–cuckoo–land). These words were not familiar to three independent raters, were not proper nouns, and did not exhibit repeated syllables (e.g., the prefix *PRO*– or the suffix –*ION*). Their length ranged from 7 to 17 letters and their visual appearance was changed by differentially alternating between uppercase and lowercase letters between the first and second exposures (e.g., *PaNtOkRaToR* and *pAnToKrAtOr*).

Procedure. First, the secondary motor tasks (see below) were introduced to participants by the experimenter and practiced for several minutes. Then, participants were seated in front of a PC and told that they had to rate the likeability of various stimuli that may be used in subsequent studies. Specifically, they were asked to read the words appearing on the computer screen, watch the characters, and spontaneously indicate how much they liked them by clicking on a button on the screen corresponding to a 7-point Likert scale ranging from −3 (*I do not like it at all*) to 3 (*I like it very much*). Note that this task does not require the words to be pronounced. Participants were also told that the stimuli could appear repeatedly. In the study phase, in three separate blocks (one block for each stimulus type, in which the sequence of blocks was rerandomized anew for each participant), 10 randomly chosen characters, 10 randomly chosen words, and 10 randomly chosen words typed in alternating uppercase and lowercase (randomly chosen anew for each participant) were presented, followed by a break of self-determined length. Then, in the crucial test phase, the old characters and words were presented again, as well as the old words typed in uppercase and lowercase alternation (however, typed in a different uppercase and lowercase alternation within a word, see Figure 1). Additionally, 10 new characters, 10 new words, and 10 new words typed in uppercase and lowercase alternation were presented intermixed with the old stimuli in a random order, rerandomized for each participant. Again, the stimuli appeared in three different blocks separated by stimulus type (with the sequence of blocks randomized). After this, participants were debriefed, compensated with candy, and excused.

Motor tasks. Motor tasks were manipulated between participants. The secondary motor tasks were to be performed during the whole experimental session. In the group executing a manual motor task, participants were asked to gently knead a soft foam ball in their left hand while making their liking judgments using the computer mouse with the right hand (cf. M. Wilson & Emmorey, 1998). In the group executing an oral motor task, participants were asked to chew gum (e.g., Campbell et al., 1991). To control the pace of the motor tasks, participants were instructed to knead or to chew, respectively, according to the rhythm of a metronome ticking at 60 Hz in the background.

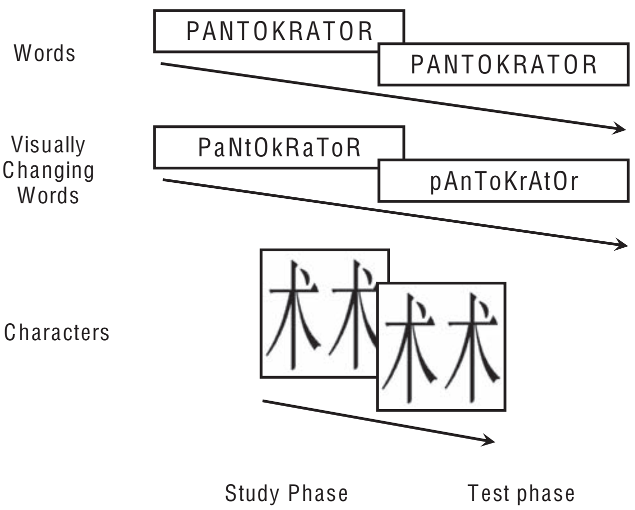

Figure 1. Overview of the experimental procedure in Experiment 1.

Results

The liking ratings in the test phase were entered into a 3 (stimulus: Chinese characters, words appearing visually equally in study and test phase, words appearing visually altered in study and test phase) × 2 (exposure: old items, new items) × 2 (motor task: manual, oral) mixed analysis of variance (ANOVA) with motor task as the between-subjects factor. We obtained a significant main effect of stimulus, $F(1, 57) = 21.88$, $p < .001$, $\eta_p^2 = .43$, indicating that across conditions Chinese characters (old and new) were more liked ($M = 4.56$, $SD = 0.62$) than both the words (old and new; $M = 3.92$, $SD = 0.60$), $t(59) = 5.67$, $p < .001$, $d = 1.06$, and the visually altered words (old and new; $M = 3.96$, $SD = 0.58$), $t(59) = 6.10$, $p < .001$, $d = 1.00$. Liking ratings did not differ between words and visually altered words ($t < 1$). In addition, we obtained a main effect for exposure, $F(1, 58) = 40.75$, $p < .0001$, $\eta_p^2 = .41$; a marginal interaction between exposure and motor task, $F(1, 58) = 3.64$, $p = .06$, $\eta_p^2 = .06$; an interaction between stimulus and exposure, $F(1, 57) = 3.92$, $p < .025$, $\eta_p^2 = .12$; and, most important, a three-way interaction between stimulus, exposure, and motor task, $F(1, 57) = 5.55$, $p < .006$, $\eta_p^2 = .16$, which justifies separate analyses for each motor task (see Table 1 for all condition means).

Manual motor task. In the group engaged in kneading a foam ball, we found a main effect of exposure, $F(1, 29) = 30.61$, $p < .0001$, $\eta_p^2 = .51$ (besides the omnibus effect of stimulus, which is reported above and is left out from here on), and, most important, no interaction between exposure and stimuli ($F < 0.44$). Consequently, old items were liked more ($M = 4.31$, $SD = 0.49$) than new items ($M = 3.99$, $SD = 0.36$), $t(29) = 5.53$, $p < .0001$, $d = 0.74$, which was true for characters, words, and visually changing words (all ts > 3.6; all ps < .002).

Oral motor task. In the group chewing gum, we found a main effect of exposure, $F(1, 29) = 11.41$, $p < .002$, $\eta_p^2 = .28$, which was qualified by an interaction between exposure and stimulus, $F(1, 28) = 5.85$, $p < .008$, $\eta_p^2 = .30$. Here, old characters were liked more ($M = 4.80$, $SD = 0.69$) than new characters ($M = 4.27$, $SD = 0.70$), $t(29) = 4.70$, $p < .0001$, $d = 1.07$; however, liking ratings did not differ between old and new words ($t < 0.02$) and old and new visually changing words ($t < 0.03$).

Discussion

Although mere exposure of visual characters was not impaired by any of the motor tasks (obviously because neither concurrent oral nor manual muscle activity interfered with the visual processing of the characters), mere exposure for words was selectively attenuated by concurrently moving the mouth but not by moving the hand. To our surprise, the attenuation of mere exposure effects for words through articulatory suppression was true not only for words that appeared visually altered in the second presentation (leaving motor fluency in reading the words as the only available cue for the evaluation) but also for words that remained visually

Table 1
Mean Liking Ratings in the Test Phase of Experiment 1 as a Function of Secondary Motor Task, Stimulus Type, and Frequency of Exposure

	Secondary motor task							
	Manual (kneading a soft ball)				Oral (chewing gum)			
	New items		Old items		New items		Old items	
Stimulus type	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Chinese characters	4.44	0.11	4.74	0.13	4.27	0.13	4.79	0.13
Words with same visual appearance in study and test phase	3.79	0.12	4.11	0.12	3.89	0.10	3.89	0.15
Words with different visual appearance in study and test phase	3.74	0.10	4.09	0.13	4.01	0.11	4.01	0.10

Note. Scale ranged from 0 (*I do not like it at all*) to 6 (*I like it very much*).

the same from the first to the second exposure (providing the visual fluency as an alternative cue). This finding suggests that participants may have always relied on the motor fluency and may not have switched to perceptual fluency as an alternative cue. Thus, mere exposure for words seems to be largely driven by variations in the fluency of oral motor simulation.

It might be objected that the chewing participants may have attributed the fluency-triggered positive affect of old items to the hedonic experience of chewing the tasty gum, and evaluations may thus have become insensitive to mere exposure. However, this case should also apply to characters, for which mere exposure effects remained stable.

Nevertheless, Experiment 2 should rule out this possibility by using a neutral oral motor task. In addition, Experiment 2 investigated whether the concurrent motor activity in the mouth works during the first or the second exposure. Finally, Experiment 2 addressed the question of whether an evaluative mindset during the first exposure is necessary for the patterns found in Experiment 1.

Experiment 2

Articulatory suppression blocked mere exposure effects for words but not for Chinese characters. We argue that concurrent mouth activity blocks mere exposure even when applied only during the first exposure (because the motor programs cannot be trained) or only during the second exposure (because the motor programs are trained but are not simulated and thus cannot yield fluency gains for old items). Experiment 2 implements these two manipulations. Furthermore, in Experiment 1, participants evaluated the stimuli during both the first and the second exposure. We argue that an evaluation during the first exposure is not necessary to produce the obtained pattern. Thus, the present experiment implemented a condition in which the study phase did not involve an evaluation of the stimuli. Finally, the findings of Experiment 1 should be generalized using a different oral motor task that does not entail a potentially hedonic experience (like chewing gum), namely, covertly whispering a task-irrelevant word (cf. Campbell et al., 1991; Miyake et al., 2004).

Method

Participants. Sixty-four (32 women, 32 men) nonpsychology students participated for a small candy gift as compensation.

Materials and procedure. The characters and normally typed words from Experiment 1 were used and were again, as in Experiment 1, presented in separate blocks for each stimulus type. The procedure was the same except for three modifications. First, only an oral motor task was implemented. Participants were asked to continuously and covertly whisper the name of the current weekday (e.g., the German *FREITAG* for Friday) during stimulus exposure or evaluation (see below). They were trained to pronounce the particular word voicelessly while keeping the mouth shut. Second, the initial presentation involved either an evaluation of the stimuli (as in Experiment 1) or mere studying of the stimuli for which participants were asked to silently read the words or watch the Chinese ideographs, skipping from item to item by pressing a key at their own pace. Third, participants were asked to whisper either during the first presentation of stimuli (study phase) or during the second presentation of stimuli (test phase), resulting in four between-subjects conditions (study phase with or without evaluation, whispering during study or during test phase, $n = 16$ in each group).

Results and Discussion

Running a 2 (stimulus: characters, words) × 2 (exposure: old items, new items) × 2 (evaluation: evaluation during the first presentation, mere study during the first presentation) × 2 (time of oral motor task: during first presentation, during second presentation) mixed ANOVA, with the two latter factors as between-subjects factors, we found a main effect of stimulus, $F(1, 30) = 17.34$, $p < .0001$, $\eta_p^2 = .37$; a main effect for exposure, $F(1, 30) = 8.85$, $p < .01$, $\eta_p^2 = .23$, which was qualified by a significant interaction between stimulus and exposure, $F(1, 30) = 5.01$, $p < .02$, $\eta_p^2 = .14$; and no other effects (all Fs < 2). Consequently, across all groups, Chinese characters ($M = 4.49$, $SD = 0.73$) were more liked than words ($M = 3.89$, $SD = 0.53$), $t(63) = 6.49$, $p < .001$, $d = 0.95$. More important, old characters were liked more ($M = 4.82$, $SD = 0.88$) than new characters ($M = 4.16$, $SD =$

0.89), $t(63) = 5.32$, $p < .001$, $d = 0.75$. However, there was no difference in liking ratings for old words ($M = 3.88$, $SD = 0.55$) and new words ($M = 3.90$, $SD = 0.58$; $t < 1$), which was true for all groups (see Table 2 for all condition means).

The present experiment generalizes the findings from Experiment 1 by implementing a different motor task, namely, continuously whispering a name. This neutral, even monotonous motor task was equally as effective as chewing in blocking mere exposure, which renders it unlikely that chewing gum destroyed the mere exposure effects because of its own hedonic features. Again, mere exposure was blocked selectively for words and not for characters. Most important, this blocking worked for participants both evaluating and merely studying the stimuli during the first presentation and independently of whether participants whispered exclusively during the first or the second presentation.

The condition in which the oral motor task was exclusively implemented during the first presentation also demonstrates that preferences did not attenuate because the oral motor task impairs the general verbal processing of the to-be-evaluated words in the test phase (cf. Campbell et al., 1991), because in this condition, participants were not occupied with any secondary task in the test phase.

In the final experiment, we wanted to generalize our embodied account of mere exposure to another stimulus and motor domain, namely, melodic stimuli, which is another classical stimulus type from mere exposure research (e.g., Heingartner & Hall, 1974; Peretz et al., 1998; W. R. Wilson, 1979). As already outlined in the introduction, we assumed that blocking oral motor simulations would selectively impair mere exposure effects for words but not for melodies; whereas blocking vocal motor simulations would impair mere exposure effects selectively for melodies but not for words. In the following, we more thoroughly outline our assumptions concerning vocal motor simulations.

Mere Exposure of Melodies and Motor Simulations in the Vocal Folds

The human voice is produced by the vocal folds, which are located within the larynx (i.e., the voice box) above the trachea (i.e., the windpipe that conducts the air from the lungs) and which vibrate when air is passing with high pressure through the trachea (e.g., Titze, 1994). The vocal folds are equipped with the vocalis muscle, which exerts an influence on their tension. Increased tension of the vocal folds results in increased voice pitch (i.e., the fundamental frequency of the voice), enabling the vocal folds to flexibly tune voice pitch (Thurman & Welch, 2000; Titze, 1994). Derived from the notion of a perception–behavior link (Chartrand & Bargh, 1999), the motor simulation that we assume takes place while listening to music consists of automatically simulating the variations in tone pitches of the melodic stimulus by covertly simulating the degrees of tension and relaxation of the vocalis muscle that correspond to the particular tone pitches of the external melody. As was shown before, individuals automatically imitate pitch patterns of other speakers' voices (e.g., Gregory, 1990; Zebrowitz, Brownlow, & Olson, 1992). Comparable to the learning of a sequence of motor reactions (cf. Nissen & Bullemer, 1987), the sequence of pitch variations is trained by this vocal motor simulation, resulting in an increased motor fluency (cf. Shanks & Johnstone, 1999) of this vocal simulation when the melody is repeatedly encountered (and again automatically imitated). We deem this increased motor fluency (e.g., Destrebecqz & Cleeremans, 2001) to be responsible for increased preference for old melodies (e.g., W. R. Wilson, 1979). In the final experiment, we wanted to block vocal motor simulation in order to investigate its impact on mere exposure for melodic stimuli.

Experiment 3

The present experiment attempts to demonstrate that mere exposure effects for stimuli that are associated with different motor systems depend on specific motor simulations in these different motor systems by specifically blocking motor simulations. Provoking a double dissociation we expected that under an oral motor task, mere exposure would be obtained for tone sequences but not for words; however, under a vocal motor task, mere exposure would be obtained for words but not for tone sequences. As a differentiation, we manipulated the similarity of the melodic stimuli with the human voice, by including records of tone sequences

Table 2
Mean Liking Ratings in the Test Phase of Experiment 2 as a Function of Stimulus Type, Frequency of Exposure, Evaluation, and Concurrent Motor Task

	Stimulus type							
	Chinese ideographs				Words			
	New items		Old items		New items		Old items	
Concurrent tasks	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Whispering in study phase, nonevaluative study phase	4.28	0.22	4.71	0.21	3.70	0.14	3.80	0.15
Whispering in test phase, nonevaluative study phase	4.26	0.22	4.75	0.21	4.13	0.14	4.06	0.15
Whispering in study phase, evaluative study phase	4.14	0.22	5.36	0.21	3.90	0.14	3.90	0.15
Whispering in test phase, evaluative study phase	3.96	0.22	4.45	0.21	3.78	0.14	3.83	0.15

Note. Scale ranged from 0 (*I do not like it at all*) to 6 (*I like it very much*).

that are either played by flute or hummed by a female voice. Because the hummed tunes are more similar to a person's own voice, we expected vocal motor simulation to be more likely for hummed than for fluted tone sequences. Consequently, we expected that under a secondary vocal task, mere exposure for hummed melodies would completely vanish but would still hold for tone sequences played by flute, though decreased in size.

Method

Participants. Sixty (38 women, 22 men) nonpsychology students participated for a reward of 2€ (~$3 at that time).

Materials. Because mere exposure effects are more likely to emerge in initially unfamiliar stimuli (Bornstein, 1989; Peretz et al., 1998), we chose unfamiliar sequences of four to nine tones from the stimulus pool provided by Thompson, Balkwill, and Vernecsu (2000), which were also used by Szpunar, Schellenberg, and Pliner, (2004). The sequences did not conform to any major or minor Western scales. A musically educated research assistant recorded these sequences either by playing them with a flute or by humming them into the microphone, respectively. Three independent raters verified that the same tone sequences, played by flute or hummed, respectively, exhibited equal amplitude and duration and that amplitude and duration of single notes did not change within a particular sequence (thus only featuring variations in pitch, not in rhythm, see Krumhansl, 2000; Peretz & Zatorre, 2005). As nonsense words, we used the same words from Experiments 1 and 2.

Procedure. Participants were told that the experiment was intended to assess evaluative judgments in multitasking. They were asked to rate the likeability of various stimuli for implementation in later studies while doing a secondary task. Next, the secondary motor task (see below) was introduced to them and carefully practiced for several minutes. They were then seated in front of a PC screen and asked to put on headphones. They were instructed to read the appearing words and listen to the tunes played to them via the headphones and to spontaneously indicate their liking of each stimulus by clicking the corresponding button on the PC screen on a 7-point Likert scale ranging from 0 (*I do not like it at all*) to 6 (*I like it very much*). Note that this task does not require participants to pronounce the words or to hum the melodies. They were also told that the stimuli could appear repeatedly. They were then asked to start executing the motor task and the experimental block began. In the study phase, six randomly chosen words, six randomly chosen tone sequences played by flute, and six randomly chosen hummed tone sequences (rerandomized for each participant) were presented in three separate blocks (one block for each stimulus type). The sequence of these three blocks was rerandomized for each participant. Tonal sequences played by flute were not identical to those hummed. Then a break of self-determined length followed in which participant could stop executing the secondary motor task. In the crucial test phase, in three separate blocks (one block for each stimulus type, randomized in their sequence), the old words and melodies together with six new words, six new tone sequences played by flute, and six new hummed tone sequences were presented in random order, rerandomized for each participant. Again, fluted and hummed melodies were not identical to each other. After this, participants were debriefed, paid, and excused.

Secondary motor tasks. The secondary motor task was manipulated between participants and was executed during both the study phase and the test phase (i.e., during the whole experiment). In general, we wanted to use simple motor tasks that could be executed automatically and did not add to cognitive load. In the oral-block condition, participants were asked to alternately tap with the tip of the tongue on the inside of the right or left corner of the mouth while keeping the mouth shut. This exercise should engage two central effectors in human articulation (e.g., Inoue et al., 2007), namely, the tongue (moving from side to side and forward and backward) and the lips (asserting a counter pressure against the pushing of the tongue in order to keep the mouth shut). This motor task was chosen instead of conventional methods of articulatory suppression (e.g., saying a task-irrelevant word, Miyake et al., 2004) because it is not associated with a vocal muscle activity. Even voicelessly whispering a word might have affected muscle activity in the vocal folds. To rule out that effects might be driven by task demand or might have elicited shame in nonmusical participants, we wanted to use a simple tune consisting of at least two tones in the vocal-block condition. We decided to use the well-known "mm-hm" a listener hums when agreeing with the speaker and signaling that the speaker should continue, which is a paraverbal response token entailing a prosody of two tones in an iamb with rising pitch (Gardner, 2001). This tune was expedient because of two reasons. First, (Western) individuals have overlearned the performance of this tone sequence, because this response token is very frequently used by listeners in everyday conversations to stimulate the narration of the speaker (called a *continuer*, Gardner, 2001), thus they are used to performing this tone sequence automatically and while listening to an external source. Second, it entails two different tone pitches that have to be alternately performed, which complicates a concurrent imitation of the external melody. In the case of humming a single tone, for example, it is conceivable that while listening to the external tune, the pitch of this single tone might gently be varied by participants in order to accommodate to the current pitch of the external tune, that is, slightly descending when the current tone pitch of the tune is low and slightly ascending when the current tone pitch of the tune is high, hence again resulting in a covert motor simulation. Alternately performing two different tone pitches should complicate a hidden motor simulation. Participants were trained to perform the tune with the mouth closed (leaving the muscles responsible for pronunciation free to motor simulate). Using exemplary tone sequences featuring the same amplitude as the later experimental stimuli, participants were also trained to hum this melody so gently that they could properly hear the tonal sequences through the headphones (assessed via personal interviews before the experimental session). To control the pace of the motor tasks, participants were instructed to tongue tap or to hum, respectively, according to the rhythm of a metronome ticking at 60 Hz in the background.

Results

Over the liking ratings in the test phase, a 3 (stimulus: words, melodies by flute, hummed melodies) × 2 (exposure: old items, new items) × 2 (secondary task: oral, vocal) mixed ANOVA was run with secondary task as the between-subjects factor. We obtained a main effect for stimulus, $F(1, 57) = 6.21$, $p < .004$, $\eta_p^2 =$

.18, indicating that across conditions and exposure frequencies, words (M = 3.56, SD = 0.86) and hummed melodies (M = 3.74, SD = 0.84) were liked less than melodies played by flute (M = 4.17, SD = 1.07; both ts > 2.6, ps < .02), with no statistical difference between words and hummed melodies ($t < 1.27$). In addition, we obtained a main effect of exposure, $F(1, 58) = 17.54$, $p < .001$, $\eta_p^2 = .23$, which was qualified by a three-way interaction between stimulus, exposure, and secondary task, $F(1, 57) = 5.57$, $p < .006$, $\eta_p^2 = .16$. Note that (see below in the *Discussion*) we did not find a main effect of secondary task ($F < 1$), because overall liking ratings for all stimuli did not differ between the oral (M = 3.80, SD = 0.46) and the vocal motor task group (M = 3.85, SD = 0.64; $t < 1$). Because of the significant three-way interaction, the data were further analyzed separately for each secondary task. Conducting separate analyses for each stimulus type yielded the same pattern of results.

Oral motor task. For the liking ratings of participants tapping with the tongue, we found a main effect for stimulus, $F(1, 28) = 4.97$, $p < .02$, $\eta_p^2 = .26$ (reflecting the pattern reported in the omnibus analysis above), and a main effect of exposure, $F(1, 29) = 10.93$, $p < .003$, $\eta_p^2 = .27$, which was qualified by an interaction between exposure and stimulus, $F(1, 28) = 2.77$, $p < .05$, $\eta_p^2 = .17$. As can be seen in Table 3, no difference occurred between old and new words ($t < 1$); however, old fluted melodies were liked more than new fluted melodies, $t(29) = 3.48$, $p < .002$, and old hummed melodies were also liked more than new hummed melodies, $t(29) = 2.19$, $p < .04$.

Vocal motor task. For the liking ratings of participants humming "mm-hm," we found only a main effect for exposure, $F(1, 29) = 6.61$, $p < .02$, $\eta_p^2 = .19$, that was qualified by an interaction between exposure and stimulus, $F(1, 28) = 3.83$, $p < .04$, $\eta_p^2 = .22$. Here, no differences occurred between old and new melodies (ts < 1); however, old words were liked more than new words, $t(29) = 3.43$, $p < .002$ (see Table 3). In contrast to our expectations, mere exposure effects were blocked for both fluted and hummed melodies (which we discuss in the General Discussion).

Discussion

Generalizing our embodied account of mere exposure, we again showed that mere exposure effects are driven by motor simulations in those motor systems that are specifically linked to a particular stimulus (cf. Chao & Martin, 2000; Kato et al., 1999). We achieved this result by using two classes of stimuli that are specifically associated with two different motor systems, namely, words, which are performed by oral muscles (Inoue et al., 2007), and tunes, which are performed by the vocal folds (Titze, 1994). Concurrent with a repeated exposure of these stimuli, two secondary motor tasks were implemented that selectively blocked either oral motor simulations (tapping with the tip of the tongue on the inside of the lip corners) or vocal motor simulations (continuously performing the response token "mm-hm"). The findings show a double dissociation such that the concurrent oral motor task destroyed mere exposure effects for words but not for tunes; however, a concurrent vocal motor task destroyed mere exposure effects for tunes but not for words. Two possible confounding factors of the vocal motor task are discussed below, which are a possible auditory distraction and the affective valence of this task.

Humming made melodic stimuli less audible. Certainly, a confounding difference between an oral and a vocal task is that the latter produces a sound, namely, one's own voice. An experimental approach to deal with this confounding factor would have been to present the nonwords acoustically. However, we decided to replicate the classical mere exposure paradigm for words, namely, to ask participants to read them.

It might be argued that mere exposure effects for the tone sequences vanished under the vocal task simply because the melodies were less audible compared with the noiseless oral task. This interpretation, however, is unlikely, because mere exposure effects for melodic stimuli are very robust against distracting sounds. W. R. Wilson (1979, Experiment 2) used a dichotic-listening paradigm in which participants received repeating melodic sequences in the unattended channel while listening to a distractor message in the attended channel. Even when participants shadowed the verbal material played to them (i.e., speaking out loud each word as they heard it in the attended channel), mere exposure effects were still found (see also the General Discussion). Furthermore, Szpunar et al. (2004) used the same dichotic-listening paradigm but substantially reduced the amplitude of the melodic stimuli in the unattended channel. They still obtained mere exposure effects, which renders it unlikely that mere exposure effects attenuated in the present vocal condition because melodies became less audible. Finally, the present results are also running against this interpretation. The fluency literature tells us that stimuli are liked more when they are easier to perceive (e.g., Reber et al.,

Table 3
Mean Liking Ratings in the Test Phase of Experiment 3 as a Function of Secondary Motor Task, Stimulus Type, and Frequency of Exposure

	Secondary motor task							
	Oral (tongue tapping)				Vocal (performing "mm-hm")			
	New items		Old items		New items		Old items	
Stimulus type	M	SE	M	SE	M	SE	M	SE
Words	3.52	0.90	3.52	0.96	3.32	0.86	3.88	1.04
Hummed melodies	3.46	0.72	3.77	0.79	3.90	1.06	3.84	0.91
Melodies played by flute	3.98	1.28	4.56	1.34	4.05	1.19	4.10	0.92

Note. Scale ranged from 0 (*I do not like it at all*) to 6 (*I like it very much*).

2004). If humming made the melodies less audible and thus less easy to perceive, one should expect that melodies were less liked in the vocal than in the oral condition, which, however, was not true (see Table 3).

The response token "mm-hm" entails a positive valence that obscured mere exposure effects. It might be argued that the vocal motor task we applied, namely, continuously humming "mm-hm" (Gardner, 2001), can be seen as an affirmative nonverbal response token eliciting positive affect, which leads to an increased liking of all stimuli and results in a ceiling effect that obscures increased liking for old stimuli. However, we did not find such ceiling effects as humming did not increase the overall liking compared with tongue tapping (see *Results*). Finally, there is no explanation for why this confounding factor only reduced mere exposure for melodies but not for words (see also the *Discussion* of Experiment 1 for hedonic valence of chewing gum).

General Discussion

We proposed and tested an embodiment account for mere exposure effects. We argued that the mere presentation of a stimulus triggers simulations of the motor programs specifically associated with that stimulus (cf. Barsalou, 1999; M. Wilson, 2002). When a stimulus is repeatedly encountered, the covert motor simulation is trained and becomes increasingly fluent (cf. Forster & Davis, 1984; Savage et al., 1990; Scarborough et al., 1977). Finally, we suggest that it is the fluency of this motor simulation that causes increased liking of repeated stimuli because high fluency triggers positive affect (e.g., Reber et al., 1998; Winkielman et al., 2003). In the present studies, we blocked covert motor simulations by involving certain motor systems in secondary tasks, which destroyed mere exposure effects for stimuli that are specifically linked to the respective motor systems.

By having participants chew gum (Experiment 1) or covertly whisper the name of the current weekday (Experiment 2), we found that mere exposure effects for words disappeared, whereas mere exposure effects for visual stimuli (Chinese characters) remained unaffected. We showed that the blocking of motor simulations worked when participants evaluated or merely studied the stimuli during the first encounter and when articulatory suppression was applied during the study or the test phase (Experiment 2). We also demonstrated that it was the fluency of oral motor simulations that drove mere exposure for words, because a concurrent manual motor task failed to impair mere exposure effects for words (Experiment 1). Finally, we provoked a double dissociation in engaging either the oral muscles (responsible for pronouncing words) or the vocal muscle (responsible for performing melodies) in a secondary motor task during the repeated exposure of words and melodies (Experiment 3). We found that blocking oral motor simulations sabotaged mere exposure effects for words but not for melodies; however, blocking vocal motor simulations sabotaged mere exposure for melodies but not for words. These findings suggest that mere exposure effects are driven by stimulus-specific motor simulations. In the following, we discuss some implications for an embodiment account of mere exposure.

Implications

The present approach applies our knowledge about sensorimotor fluency (cf. Beilock & Holt, 2007; but also see, for different sensorimotor domains, Simon & Small, 1969; Tucker & Ellis, 1998) to the domain of mere exposure in showing that the training of covert motor simulations drives increased liking for repeated stimuli. This finding opens a broad range of research questions. For example, can we identify the sensorimotor source of fluency gains for any stimulus type? The most interesting case surely is visual characters, the classical example of mere exposure literature (e.g., Zajonc, 1968). At first glance, one would expect visual fluency to be the underlying source, which would imply that mere exposure for visual stimuli might disappear if individuals are concurrently engaged in a visual imagery task (simulating different visual inputs). However, it is also conceivable that additively, motor fluency may be involved, which would imply that mere exposure for visual stimuli would disappear if the ciliary muscles were paralyzed (because they are the only muscles involved in visual processing; Palmer, 1999). These exemplary questions illustrate the diversity of highly interesting and innovative research questions that may be stimulated by an embodied account of mere exposure. In the remainder of this article, we more thoroughly discuss further implications.

Os Fabrum—The Strenuous Mouth

The present work demonstrates how tirelessly the mouth, the central effector in speech, continuously mirrors verbal stimuli and shapes our affective responses to the words we perceive. A convergent finding demonstrating the relationship of repeated exposure and (c)overt articulatory fluency can be found in Poldrack and Cohen (1997). They established arbitrary associations between word pairs that had to be read aloud. After a few presentations of the word pairs, participants were faster in reading old pairs compared with newly combined pairs (Experiment 1). This advance, however, disappeared when word positions in old pairs were reversed (study *MOTOR–MOUTH* but test *MOUTH–MOTOR*; Experiment 2), implying that no abstract associations had been learned but rather only specific lower level features of the word pairs. Finally, this pairing-specific effect disappeared when the word *AND* was inserted between the words of a given pair (Experiment 3). This surprising finding indicates that the articulatory fluency in the transition from one word of a given word pair to the other word actually drove the priming of the new associations.

The question is, which other verbal priming or verbal learning effects are also driven by covert articulatory simulation? Take, for example, artificial grammar learning (Reber, 1967), in which individuals are initially exposed to letter strings that conform to a set of hidden rules (grammar) too complicated to be consciously extracted. Then, in a later test phase, new letter strings are presented that either conform to the hidden rules (grammatical) or not (agrammatical). In general, individuals are able to discriminate grammatical from agrammatical items above chance without being able to extract the underlying rules. The fluency in processing the letter strings has been identified as a factor that drives this faculty (e.g., Johnstone & Shanks, 2001; Servan-Schreiber & Anderson, 1990), and the intuitive judgments of grammaticality can actually be influenced by changing the processing fluency of the letter strings experimentally (e.g., Kinder, Shanks, Cock, & Tunney, 2003). However, the source of the fluency still needs to be identified. Given the present findings, it is plausible that individuals covertly articulate the letters when they encounter a letter string.

Thus, it is conceivable that through repeated covert articulation, the transitions between the motor programs for the letters are trained (as in Poldrack & Cohen, 1997, see above), resulting in more fluent covert articulation for grammatical items. It follows from this idea that implicit learning could be blocked by simply letting participants chew gum, a speculation that should be tested in further research.

Voice Box Mimicry for Music

We found that blocking vocal motor simulations impaired mere exposure not only for hummed but also for fluted melodies. This finding is astonishing because it suggests that our vocal folds may automatically simulate not only features of other peoples' voices (cf. Gregory, 1990) but also features of melodies played by an instrument. In our work, these simulations must have resembled the pitch relations in the melodies not their rhythmical pattern (see Krumhansl, 2000; Peretz & Zatorre, 2005) because lengths and amplitudes did not differ between single tones and tone sequences.

This online voice box mimicry can be related to current findings from neuroscience concerning the human mirror-neuron system (for a review, see Rizzolatti & Craighero, 2004). Neurophysiological evidence shows that the motor cortex is activated when individuals observe an action executed by another individual, even in the absence of their own overt motor response (e.g., Cochin, Barthelemy, Roux, & Martineau, 1999; Hari et al., 1998). For the case of speech and oral motor simulations, recent brain imaging studies demonstrated that seeing and hearing another person speaking automatically triggers activity in the motor areas responsible for speech production (Fadiga, Craighero, Buccino, & Rizzolatti, 2002; Watkins & Paus, 2004; Watkins, Strafella, & Paus, 2003).

Given these findings concerning sensorimotor overlaps, the present finding is another example of the fact that in the cognitive system, stimuli and responses are represented in a commensurable format (e.g., Meltzoff & Prinz, 2002). If this is correct, one would expect similar brain activity in the motor cortex when individuals sing or just listen to music. Furthermore, one could predict that both singing and listening to music would have the same impact on the formation of motor memory, because we know that the mere observation of a motor task increases later performance in executing that task (e.g., Brass, Bekkering, & Prinz, 2001; Stefan et al., 2005), which would imply that one could increase singing performance not only by singing but also by just passively listening to music, which would have strong implications for vocal pedagogy. Further research should investigate whether passive listening to music influences singing performance, for example, setting the right tone or carrying a tune.

Convergent evidence can be found in brain-imaging studies that imply a motor component in pitch perception independently of actual vocal performance (of course, besides a massive activation in the auditory cortex, Peretz & Zatorre, 2005; but also see Schubotz, 2007, for the claim that only auditory information is simulated when an individual passively listens to music). Halpern and Zatorre (1999) detected activation in the supplementary motor area when participants imagined a familiar tune and concluded that a motor code was involved (see also Halpern, Zatorre, Bouffard, & Johnson, 2004), which may relate to motor imagery, as Peretz and Zatorre (2005) stated. Also, Gaab, Keenan, and Schlaug (2003) found an increase in cerebellar activation during a pitch memory task. Finally, in Janata et al. (2002), musically experienced listeners heard tone sequences and rated their tonality (a task involving only the assessment of pitch relations not rhythmical parameters), which also activated the cerebellum (among other areas). Though speculative, it is conceivable that future research—using physiological or brain-imaging approaches—may detect that this motor component is linked to the vocal folds.

Involved Motor Programs

The present work used rather restricted motor programs as secondary tasks (rhythmically chewing gum, whispering a name, performing two well-defined tongue movements and two well-learned voice pitches), which blocked motor simulations related to concurrently perceived stimuli. The question is how restricted the motor programs have to be in order to sabotage motor training. Would mere exposure effects still hold when the specific motor system is occupied, but with a less restricted task? There is a hint in the literature that was already mentioned in the discussion of Experiment 3. In a dichotic-listening paradigm, W. R. Wilson (1979, Experiment 2) let participants speak out loud each word they heard in the attended channel while they received melodies in the unattended channel. This procedure obviously occupied participants' vocal folds; however, mere exposure effects were still found for the melodies in the unattended channel. It is conceivable that speaking out loud still enabled participants to simulate the melodies played to them by gently accommodating their prosody to the pitch variations in the melody (cf. Gregory, 1990). Thus, this secondary task was not restricted enough to prevent motor training.

Even more interesting is the finding that free motor activation per se need not result in blocking underlying motor simulations. Consider Reed and Farah's (1995) finding that free motor activity (moving one's arms or legs in a continuous and random fashion without repeating a movement) may even facilitate task-related motor simulations (detecting changes in the arm and leg positions of a target person; see also the debate between Graziano, Smith, Tassinary, Sun, & Pilkington, 1996, and Zajonc & Marcus, 1984, concerning underlying facial motor simulations in recognizing emotional expressions). From this finding, one could even predict increased mere exposure for unrestricted concurrent motor activity compared with no concurrent motor activity at all. Future research should definitely address this possibility. In a related vein, further research should investigate whether the present effects are localized on the level of action planning or online control of the movement execution (e.g., Glover, 2004).

Conclusion

In summary, by adopting an embodied view, the present work provides a procedural explanation of mere exposure by showing that stimulus-specific motor simulations that run increasingly fluently through the repeated exposure of stimuli drive increased preference for repeated stimuli.

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