Front in the Mouth, Front in the Word:

The Driving Mechanisms of the In-Out Effect

Ira Theresa Maschmann

University of Cologne

Anita Körner

University of Kassel

Lea Boecker

Leuphana University of Lüneburg

Sascha Topolinski

University of Cologne

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Please address correspondence to: Ira Theresa Maschmann, Social and Economic Cognition II

University of Cologne, Richard-Strauss-Strasse 2, 50931, Cologne

E-mail: ira.maschmann.psych@gmail.com

Abstract (242)

Words for which the consonantal articulation spots wander from the front to the back of the mouth (inward) elicit more positive attitudes than words with the reversed order (outward). The present paper questions the common theoretical explanation of this effect, namely an association between articulation movements and oral movements during ingestion and expectoration (inward resembles eating which is positive; outward resembles spitting which is negative). In four experiments (total *N* = 468), we consistently replicated the basic in-out effect; but no evidence was found supporting an eating-related underlying mechanism. The in-out effect was not modulated by disgust inductions (Experiments 1, 2, 4, and 10) or food deprivation (Experiment 3). In six further experiments (total *N* = 1,067), we explored a novel alternative explanation, namely that the in-out effect is simply a position-specific preference for front consonants over back consonants. In these experiments, we found in-out-like preference effects for fragments that lacked an actual front-to-back movement but featured only starting (e.g., B _ _ _ _) or ending (e.g., _ _ _ K) consonants (Experiments 6–8). Consonants that are articulated in the front of the mouth were generally preferred over those articulated in the back of the mouth, and this basic preference was stronger at the beginning of a word-like stimulus (Experiments 6–10), thus explaining the preference pattern of the in-out effect. The present evidence speaks against an eating-related (embodied) explanation and suggests a simple word-morphologic explanation of the in-out effect.

Key words: language; articulation; preference

Introduction

In the last years, a novel psycholinguistic effect on attitudes has been documented in numerous papers by several independent labs, the so-called *in-out effect*. This effect was originally published in the *Journal of Personality and Social Psychology* (Topolinski, Maschmann, Pecher, & Winkielman, 2014) and has sparked over 15 replication and extension papers in the highest outlets of psychology and marketing. In the original demonstration, Topolinski et al. (2014) showed that specific consonantal articulation patterns affected attitudes. Specifically, they construed words for which the articulation spots of the consonants moved either from the front of the mouth to the back (inward, such as in BENOKA) or from the back of the mouth to the front (outward, such as in KENOBA). In the original publication as well as in various later lines of research, it was found that words that feature inward articulation patterns (*inward words*) are preferred over words that feature outward articulation patterns (*outward words*; Topolinski et al., 2014; Topolinski, Boecker, Erle, Bakhtiari, & Pecher, 2017). This occurs even under silent reading, when participants only hear a speaker uttering such words (Topolinski & Boecker, 2016a), and even when the stimulus words are presented for only for only 50 ms (Gerten & Topolinski, 2018). The effect was replicated in different languages (English, German, and Portuguese) and by different independent research groups (Garrido, Godinho, & Semin 2019; Godinho & Garrido, 2016, 2017; Kronrod, Lowrey, & Ackerman, 2015; Rossi, Pantoja, Borges, & Werle, 2017).

The in-out preference effect exhibits manifold social and behavioral consequences, which underline its subtle yet notable relevance. For instance, when choosing chat partners for an interaction, people with inward-names were preferred over those with outward-names (Topolinski et al., 2014, Experiment 3, 7, and 8). Even inward persons' initials were (at least descriptively) preferred over outward initials (Topolinski & Boecker, 2016a, Experiment 5a & 5b). Concerning person perception, persons with inward names were judged to be more sociable than persons with outward names (Garrido et al., 2019). In the domain of economic decision-making, the in-out preference effect has even monetary implications. Inward brand names have been found to increase consumers' willingness-to-pay (Topolinski, Zürn, & Schneider, 2015); and profiles of eBay sellers with inward names were rated to be more trustworthy and more frequently chosen than sellers with outward usernames (Silva & Topolinski, 2018). Regarding behavioral consequences, the in-out preference influences consumer preferences (Silva & Topolinski, 2018; Topolinski, 2017), preferences for brand names (Godinho & Garrido, 2017; Godinho, Garrido, Zürn, & Topolinski, 2019), palatability ratings of food (Topolinski & Boecker, 2016b), and even food consumption (Rossi et al., 2017).

Despite the versatility and replicability of this effect, its underlying mechanisms remain unclear. The authors of the original demonstration (Topolinski et al., 2014) proposed an explanation based on ingestion-related associations between articulation and food intake.[1] The logic is the following. The oral motor system has two main functions, food intake and language production (Rozin, 1999). Moreover, the oral muscular activity for these two functions can be similar (Goyal & Mashimo, 2006). Specifically, when articulation mouth movements wander inwards, they resemble ingestive eating acts, like swallowing; and when they wander outwards, they resemble expectorative oral acts, like spitting. Through learned associations, ingestive acts are positive and expectorative acts are negative (Rozin, 1996); therefore, inward articulation induces a positive feeling and outward articulation induces a negative feeling. This association between articulation and food intake follows the broader notion of *embodiment* (Schubert & Semin, 2009), or *grounded cognition* (Barsalou, 2008), stating that the perception and production of language is shaped by non-linguistic

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[1] There are also two publications that provide (in)direct evidence for a fluency explanation of the in-out effect (Bakhtiari, Körner, & Topolinski, 2016; Körner, Bakhtiari, & Topolinski, 2019), that is, inward words are easier to articulate than outward words and are thus liked more. We will discuss the implications of the present evidence for this conjecture in the General Discussion.

sensorimotor states (e.g., Fischer & Zwaan, 2008; Körner, Topolinski, & Strack, 2015; Willems & Casasanto, 2011).

The first section of this paper will provide experiments testing implications of such an eating-related explanation. The second section will introduce and test a novel alternative word-morphologic explanation.

Part I: Testing implications of an eating-related account

Recently, research has started to test possible implications of an eating-related explanation of the in-out effect. These studies followed the logic that preference for articulation patterns would interact with the eating-related semantic meaning of the denoted object. Topolinski et al. (2017) manipulated the valence, edibility, and oral motor affordance of objects that bore either inward or outward names. The results were mixed. Extreme variations in edibility and valence of denoted objects modulated the in-out effect, in the way that participants liked outward words more than inward words when these words denoted toxic chemicals (a reversal of the in-out effect). However, when pitting object valence against oral motor affordance (e.g., mouthwash being a positive object that has to be spat out, or a pill being a negative object that still has to be swallowed), motor affordance and not object valence influenced the strength of the in-out effect, with objects requiring intake responses triggering a slightly stronger in-out effect than objects requiring expectoration responses. Controlling for valence more carefully, Godinho et al. (2019) found an in-out effect for edible, but not for in-edible products, while keeping valence constant across products.

These findings can be interpreted as providing evidence in favor of an eating-related account because they find assimilation effects between articulation and denoted (eating-related) meaning. In the first part of this paper, we will extend this evidence by manipulating eating-related internal states of the participant instead of the denoted object. Following an assimilation effect logic, internal states that are related to food intake (such as hunger) should increase the in-out effect, while states related to expectoration (such as disgust) should diminish or even reverse it. However, social psychology has documented both assimilation and contrast effects in various domains, contingent on a multitude of psychological moderators (for a recent brief review, see Bless & Burger, 2016). Also, the conceptually underspecified eating mechanism of the in-out effect does not provide highly constrained predictions regarding assimilation or contrast, nor does it offer testable process explanations. For instance, disgust could also evoke a contrast effect by rendering oral inward responses more efficient to compensate for the negativity of disgust. Also, internal states that foster inward responses (such as hunger) might overshadow articulation simulations and thereby decrease the in-out effect.

The following experiments examine whether preferences for inward over outward words are affected by eating-related internal states, leading either to assimilation or contrast. For this, we manipulated internal eating-related states with established experimental methods, supported by successful manipulation checks, to explore whether and how they interact with the in-out effect. First, disgust was induced by having participants watch disgusting video clips (Experiments 1 and 4) and by having them smell disgusting odors (Experiment 2). Second, hunger was induced by food-deprivation (Experiment 3). We tested the impact of these internal states on both preference ratings for inward and outward words (Experiments 1-3) and reading latencies (Experiment 4).

Data Treatment and a Priori Power Analysis

For the experiments reported in this paper, we report all exclusion of data (if any), all manipulations, and all measures. Materials and data for all experiments will be made public upon publication. Assuming a small effect size of $f = .14$ (and a correlation of $r = .5$ for the within-factor) to detect a 2 X 2 within-between interaction with a power of .80, *G*Power* (Faul, Erdfelder, Lang, & Buchner, 2007) yields $N_{required} = 104$. For Experiment 2, featuring a within-design, sample sizes comparable to the other experiments were collected to enhance statistical power. All experiments were part of larger experimental batteries and due to experimental flow, the actual sample sizes differ slightly from the proposed sample sizes. To test null-effects, Bayesian ANOVAs were conducted because frequentist tests are unable to quantify evidence in favor of the null-hypothesis. These analyses used the default priors offered by the software JASP (JASP Team, 2018). The experiments described were conducted on the campus of two different German universities and contain a disproportionately large number of young female participants.

Experiment 1: Visual Disgust Induction

The two first experiments induced internal states of disgust in the participants. Following an assimilation logic, disgust should activate expectoration-related kinematics, which might prime and thereby favor articulatory oral outward movements, which should attenuate the in-out effect.

Method

Participants. $N = 124$ participants (90 female, 34 male; aged 18-63 years, $M_{age} = 25$, $SD_{age} = 8$) from a local participant pool were recruited in exchange for monetary compensation of €7 or partial course credit (the experiment was part of a larger battery of experiments).

Emotion-inducing video clips. For the emotion manipulation, we used six neutral and six disgust-inducing video clips that had been used in previous experiments and verified to be neutral (de Jong, van Overveld, & Peters, 2011; Gross & Levenson, 1995; Han, Lerner, Zeckhauser, 2012; Hewig et al., 2005; Lerner, Small, & Loewenstein, 2004; Rottenberg, Ray, & Gross, 2007) or to induce disgust (de Jong et al., 2011; Gross & Levenson, 1995; Han et al., 2012; Hewig et al., 2005; Lerner et al., 2004; Rohrmann, Hopp, & Quirin, 2008; Sarlo, Buodo, Munafò, Stegagno, & Palomba, 2008; Stark et al., 2005; Tomarken, Davidson, & Henriques, 1990). The neutral video clips showed, for example, scenes of nature or everyday social scenes. The disgust-inducing video clips showed contact with bodily fluids or small animals; for example, an invasion by cockroaches or a person vomiting, thereby strongly evoking oral disgust. Each video clip lasted 28–41 seconds and was presented without sound.

Pilot test: Manipulation validation. To assure that disgust induced by videos is associated with oral outward kinematics, we let participants indicate their actual swallowing versus spitting intentions after being presented with the videos. *N* = 76 German-speaking participants were approached on campus and completed the manipulation validation study. In a between-subjects design, they were presented with three of the disgusting versus neutral videos, respectively. After they had seen the three videos, participants were asked to indicate their current oral intentions on a five-point scale ranging from 1 (*swallowing*) to 5 (*spitting*). Results showed that participants in the disgust condition rather had the intention of spitting ($M = 3.21$, $SD = 0.98$ compared to participants in the neutral condition ($M = 2.43$, $SD = 0.73$), $t(74) = 3.89$, $p < .001$, $d = 0.90$, 95% CI [0.38, 1.17], indicating that the video disgust induction employed in Experiments 1 and 4 is motivationally associated with expectoration and therefore outward kinematics.

Materials. As word stimuli, we used a subsample of 30 inward words and 30 outward words derived from Stimulus pool C designed for German phonation from Topolinski et al. (2014). To create these words, consonants of three different articulation spots on the sagittal plane of the mouth were chosen (IPA, 1999), from the front of the mouth (labial: B, M, P, W), the middle (alveolar: D, L, N, S, T), and the back (velar/uvular: G, K, R). All possible combinations of these consonants were created where the order either led inward (front-middle-back) or outward (back-middle-front). Random vowels were added, to create words which are pronounceable. Vowel phonation was not manipulated since the articulation of vowels does not contain as distinct and well-localizable muscle tensions as consonants (Ladefoged, 2001). Moreover, Topolinski and Boecker (2016a) tested the impact of forward and backward vowel jumps in two experiments and did not find any effect on preference ratings.

Procedure. After providing informed consent, participants were told that the present study examined attentional processes when switching between different tasks. They were informed that one task consisted in watching short video clips on which they were to answer questions, while the other task consisted in evaluating artificial words. We presented the emotion-eliciting videos and word evaluation in six identical short blocks. Each block started with a video clip. Then participants evaluated 10 randomly sampled in- and 10 randomly sampled outward words for liking on a nine-point scale ranging from 1 (*do not like this word at all*) to 9 (*like the word very much*). Afterwards, they were asked to evaluate the video for pleasantness on a 5-point scale ranging from 1 *(not at all pleasant)* to 5 *(very pleasant)* and answer one question concerning the content of the video (to ensure attention to all videos). Then the next block followed.

After they had completed all six blocks of emotion induction and word evaluation, a manipulation check assessing participants emotional state ensued (Merten & Krause, 1993; Cronbach' α = .93 for the disgust subscale). Finally, after a questionnaire concerning disgust sensitivity (Schienle, Walter, Stark, & Vaitl, 2002; which will not be mentioned further), participants provided demographic information, and answered a few questions concerning the video and the experiment.

Results and discussion

The manipulation check was significant. Participants in the disgust condition felt more disgusted (M = 3.49, SD = 1.18) compared to participants in the neutral condition (M = 1.20, SD = 0.38), $t(70)$ = 14.35, p < .001, d = 2.58, 95% CI [2.02, 3.13]. A 2 (Articulation direction: inward vs. outward; within-subjects) X 2 (Emotion: disgust vs. neutral; between-subjects) mixed model ANOVA found a significant main effect for articulation direction, $F(1, 122)$ = 18.67, p < .001, η_p^2 = .13, 95% CI [0.05, 0.23], with inward words (M = 4.29, SE = 0.10) being preferred over outward words (M = 4.16, SE = 0.11)—replicating the basic in-out effect. However, neither the main effect for emotion, $F(1, 122)$ = 0.01, p >.90, nor the interaction between emotion and articulation direction was significant, $F(1, 122) = 0.55$, $p = .46$, $\eta_p^2 < .01$, 95% CI [0.00, 0.04]. Thus, disgust did not modulate the in-out effect. Indeed, post-hoc tests showed that the in-out effect was significant for both emotion conditions (statistics can be found in Table 1); neutral: $t(63) = 2.19$, $p = .033$, $d_z = 0.27$, 95% CI [0.02, 0.52]; disgust: $t(59) = 4.59$, $p < .001$, $d_z = 0.59$, 95% CI [0.32, 0.87].

Table 1

Conditional means (and standard errors) for preference ratings as a function of articulation direction and video type in Experiment 1. Ratings were reported on a 1 to 9 scale.

Condition	Inward words	Outward words	d_z	95% CI	t-test
Neutral videos	4.27 (0.15)	4.16 (0.16)	0.27	0.02 – 0.52	$t(63) = 2.19$, $p = .033$
Disgusting videos	4.31 (0.15)	4.17 (0.14)	0.59	0.32 – 0.87	$t(59) = 4.59$, $p < .001$

To substantiate this notion, we conducted a Bayesian ANOVA. For the inclusion of the interaction term, a Bayes Factor of $BF_{01} = 4.268$ was found, which is conventionally described as moderate evidence against the inclusion of the additional factor into the model and thus *against* the presence of the predicted interaction.

Thus, even though the manipulation check confirms that participants in the disgust condition experienced marked disgust compared to the neutral condition and the manipulation validation study had shown that an oral expectoration intention was induced by the disgusting videos, this did not influence participants' preferences for inward compared to outward words.

Experiment 2: Olfactory Disgust Induction

The rationale of Experiment 1 was replicated with a physiologically more immediate induction of disgust, namely an unpleasant, bitter versus a pleasant, sweet odor.

Method

Participants. N = 127 (79 female, 40 male; M_{age} 28, SD_{age} = 9; for 8 participants, demographic data was not recorded) German-speaking participants were recruited via a local participant pool and participated in this study for a monetary reward of €7 or course credit.

Disgust-inducing odor. For the disgust manipulation, an unpleasant bitter odor was used; the control condition contained a pleasant sweet odor. The bitter odor was a liquid that consisted of a mixture of vinegar and dissolved cigarette ends. The sweet odor was a liquid with a chocolate note. The odors were presented in neutral non see-through bottles that were labelled with A and B and placed on the desk the participant sat on. The order in which the odors were presented was counterbalanced across participants.

Materials. The same stimulus pool as in Experiment 1 was used (Stimulus pool C from Topolinski et al., 2014) and stimuli were randomly sampled anew for each participant from the pool of 60 inward words and 60 outward words.

Procedure. Participants were informed that they had to evaluate words as possible brand names for odors. The task was divided into two blocks with a similar procedure. In the first block, participants were instructed which one of the odors to smell first. The little bottles that contained the odors were provided on the desk in front of them. After smelling the odor in a given block, 15 inward words and 15 outward words were presented on the screen in random order and were rated on their fitting for the odor on a 11-point scale, ranging from 0 (*do not like this word at all for the odor*) to 10 (*like the word very much for the odor*). After each block, as a manipulation check, the pleasantness of the odor was rated on an 11-point scale, ranging from 0 (*do not like this odor at all*) to 10 (*like the odor very much*). Then participants could rest for around 2 minutes before the second block started. In the second block, the second odor, the one that had not been smelled before, was used. Afterwards, participants provided demographic data.

Results and discussion

Mistyped responses (exceeding the scale) were discarded (6 of 6140, < 0.1 %). The manipulation check was significant, the unpleasant, bitter odor was liked less (M = 2.20, SE = 0.23) compared to the pleasant, sweet odor (M = 8.35, SE = 0.14), $t(126) = 21.58$, $p < .001$, d_z = 1.92, 95% CI [1.62, 2.21].

A 2 (Articulation direction: inward vs. outward) X 2 (Odor: bitter vs. sweet) repeated measures ANOVA found a marginally significant main effect for articulation direction, $F(1,125) = 3.48$, $p = .064$, $\eta_p^2 = .03$, 95% CI [0.00, 0.11], with inward words (M = 4.53, SE = 0.10) being preferred over outward words (M = 4.44, SE = 0.10), replicating the basic in-out effect (see statistics in Table 2). Additionally, a significant main effect for odor, $F(1, 125) = 4.65$, $p = .036$, $\eta_p^2 = .04$, 95% CI [0.00, 0.12], was found. Stimulus words were in total judged to fit better with the bitter odor (M = 4.65, SE = 0.14) than with the sweet odor (M = 4.30, SE = 0.13). Crucially there was no interaction between odor and articulation direction, $F(1, 125) = 0.19$, $p = .67$.

Table 2

Conditional means (and standard errors) for preference ratings as a function of articulation direction and olfactory disgust induction in Experiment 2. Ratings were reported on a 0 to 10 scale.

Condition	Inward words	Outward words	d_z	95% CI	t-test
Pleasant odor	4.33 (0.13)	4.27 (0.13)	0.08	-0.09 – 0.26	$t(125) = 0.94$, $p = .349$
Disgusting odor	4.73 (0.15)	4.62 (0.16)	0.13	-0.05 – 0.30	$t(125) = 1.45$, $p = .149$

This notion was substantiated by a Bayesian ANOVA, which found a Bayes Factor of BF_{01} = 7.213, constituting moderate evidence *against* the presence of the predicted interaction.

Thus, even the physiologically strong and imminent induction of disgust via odors did not modulate the in-out effect. Of course, one might argue that this olfactory induction is not related to the mouth (but obviously to the nose), but aversive smell is the strongest elicitor of disgust (Schienle, Schäfer, Stark, Walter, & Vaitl, 2005).

Experiment 3: Food deprivation

Here, we explored whether hunger would modulate the in-out effect. Physiological need states such as hunger or thirst have been shown to activate appetitive responses in the oral system (Rozin, 1996; Topolinski & Türk Pereira, 2012). Following an assimilation account, hunger should therefore increase the in-out effect by particularly priming and thus favoring oral inward kinematics. Moreover, in addition to inward and outward words, we assessed the preference for control words consisting of mixed articulation directions (see Topolinski et al., 2014, Experiment 6).

Method

Participants. *N* = 117 participants were recruited via a local participant pool and participated in this study (in a larger battery of experiments) for a monetary reward of €7 or course credit. Due to technical errors, demographic data along with the crucial hunger rating as manipulation check was only available for *N* = 114 participants (89 female, 25 male; M_{age} 27, SD_{age} = 9) which were included in the reported analysis. The other three participants were excluded from all analyses.

Food deprivation. Participants randomly assigned to the food deprivation condition (*N* = 58) were informed that the experiment would include a food deprivation and were asked to forgo any food intake within the 3 hours before the experiment. They were reminded of this requirement via a phone call by the experimenter the evening before the experiment took place. Participants who attended the experimental session in the morning hours (until 12 p.m.) were asked to consume the last food in the evening and to not consume any food in the morning. Participants in the control condition (N = 56) were instructed to have a proper meal within the three hours before the experiment to ensure that they are not hungry.

Materials. The stimulus pool that was used in the previous experiments, introduced by Topolinski et al. (2014) and containing 60 inward words and 60 outward words was extended with a control condition of 60 nonsense words that did not feature systematic inward and outward articulation patterns, for instance LIGEMO.

Procedure. Participants were informed that perception and reading processes were investigated. First, participants' hunger was recorded on a 7-point scale from 1 (*not at all hungry*) to 7 (*very hungry*). Then participants were presented with 30 inward, outward, and control words each (sampled anew for each participant) and rated them on an 11-point scale, ranging from 0 (*do not like this word at all*) to 10 (*like the word very much*). After completing the task, participants filled out a questionnaire that recorded questions concerning their commitment to the hunger deprivation-instructions and demographic data. Then, participants were paid and dismissed.

Results and discussion

The food deprivation worked, as participants in the deprivation condition reported much higher levels of hunger (M = 4.74, SE = 0.20) than participants in the control condition (M = 1.38, SE = 0.12), $t(112) = 14.33$, $p < .001$, d = 1.34, 95% CI [1.09, 1.60] and all participants reported levels of hunger that were in accordance with their deprivation condition.

A 3 (Articulation direction: inward vs. outward vs. control; within-subjects) X 2 (Deprivation: food deprivation vs. control condition; between-subjects) mixed-model ANOVA yielded a significant main effect for articulation direction, $F(2, 111) = 17.96$, $p < .001$, $\eta_p^2 = .24$, CI [0.11, 0.36], with inward words (M = 4.90, SE = 0.11) being liked more than outward words (M = 4.59, SE = 0.11) and the control words falling in-between (M = 4.73, SE = 0.10), very similar to the earlier pattern of control words (see Topolinski et al., 2014, Experiment 6; statistics can be found in Table 3). Crucially, neither the main effect of food deprivation, $F(1, 112) = 0.01$, $p = .91$, nor the interaction between articulation direction and deprivation, $F(2, 111) = 0.16$, $p = .86$, reached significance.

Table 3

Conditional means (and standard errors) for preference ratings as a function of articulation direction and food deprivation in Experiment 3. Ratings were reported on a 0 to 10 scale.

Condition	Inward words	Control words	Outward words	η_p^2	95 % CI	F-test
Saturated	4.91 (0.15)	4.75 (0.15)	4.59 (0.15)	0.29	0.09 - 0.44	$F(2, 56) = 11.34$, $p < .001$
Food deprived	4.89 (0.16)	4.70 (0.14)	4.59 (0.15)	0.21	0.04 - 0.37	$F(2, 54) = 7.09$, $p = .002$

A Bayesian ANOVA supported these results. A Bayes Factor of BF_{01} = 16.676 for this interaction was found, which is conventionally described as “strong” evidence *against* the presence of the predicted interaction. Additionally, no correlation between self-reported hunger and the magnitude of the in-out effect could be found, $r = -.01$, $p = .92$.

To conclude, neither food deprivation nor experienced hunger modulated the in-out effect. This mirrors earlier evidence that the in-out effect for ratings of palatability of dishes that were labelled with inward and outward words did not correlate with participants’ hunger (Topolinski & Boecker, 2016b; note that hunger was not manipulated actively in that earlier study).

Experiment 4: Video Disgust Induction on Reading Latencies

As a final experiment, we gauged the impact of disgust on reading latencies for inward and outward words, since it has been shown earlier that the in-out effect is partially mediated by processing fluency (Bakhtiari, Körner, & Topolinski, 2016).

Method

Participants. *N* = 100 (80 female, 18 male, 2 divers; M_{age} 23, SD_{age} = 4) were recruited via a local participant pool and participated in this study for a monetary reward of €2 or course credit.

Materials and procedure. The set-up of Experiment 1 was replicated with the following modification. Instead of indicating the liking, participants were instructed to read the respective target word as fast as possible and press the space bar once they were finished (an established measure of reading fluency, Topolinski & Strack, 2009; Bakhtiari et al., 2016). For the sake of experimental efficacy, Experiment 4 only consisted of five blocks of video and stimulus presentation instead of six as in Experiment 1.

Results and discussion

The manipulation check was significant again. Participants in the disgust condition felt more disgusted (*M* = 3.78, *SD* = 0.12) compared to participants in the neutral condition (*M* = 1.80, *SD* = 0.10), *t*(98) = 13.06, *p* < .001, *d* = 1.31, 95% CI [1.04, 1.58].

Following Bakhtiari et al. (2016), trials with latencies faster than 300 ms and slower than 3000 ms were discarded (6.7 % of all trials). A 2 (Articulation direction: inward vs. outward; within-subjects) X 2 (Emotion: disgust vs. neutral; between-subjects) mixed model ANOVA found a significant main effect for articulation direction, *F*(1, 98) = 12.13, *p* < .001, η_p^2 = .13, 95% CI [0.02, 0.23], with faster reading of inward words (*M* = 738 ms, *SE* = 24) compared to outward words (*M* = 762 ms, *SE* = 25), replicating earlier evidence (Bakhtiari et al., 2016). Emotion condition had no significant impact, *F*(1, 98) = 3.16, *p* = .079. Crucially, no interaction between articulation direction and emotion was found, *F*(1, 98) = 0.16, *p* = .69, η_p^2 < .01, 95% CI [0.00, 0.04]. Again post-hoc tests revealed a significant in-out effect in both emotion conditions (statistics can be found in Table 4); neutral: $t(49) = 2.59$, $p = .013$, $d_z = 0.37$, 95% CI [0.08, 0.65]; disgust: $t(49) = 2.73$, $p = .009$, $d_z = 0.39$, 95% CI [0.10, 0.67]. The Bayesian ANOVA yielded a Bayes Factor of $BF_{01} = 8.005$ for this interaction, constituting moderate evidence *against* the interaction.

Table 4

Conditional means (and standard errors) for reading latencies as a function of articulation direction and video type in Experiment 4. Trials < 300 ms and trials > 3000 ms were discarded.

Condition	Inward words	Outward words	d_z	95% CI	t-test
Neutral videos	696 (33)	717 (34)	0.37	0.08 – 0.65	$t(49) = 2.59$, $p = .013$
Disgusting videos	780 (35)	806 (37)	0.39	0.10 – 0.67	$t(49) = 2.73$, $p = .009$

Although we again successfully induced disgust, this aversive expectoration-related state did not modulate the in-out effect as measured by reading latencies.

Interim Conclusion

In four experiments, we tested whether manipulating eating-related internal states (inducing disgust and making people hungry) would modulate the in-out effect. Although the manipulation checks showed that our inductions were effective, the in-out effect as well as reading latency were not at all modulated by those states.

Thus, we did not find assimilation effects between articulation direction and internal eating-related states of participants, such as Godinho et al. (2019) and Topolinski et al. (2017) found for denoted eating-relating meaning of objects; nor did we find contrast effects. Instead, Bayesian analyses consistently resulted in moderate to strong evidence against a moderation of the in-out effect. This lacking modulation of the in-out effect by internal eating-related states does not necessarily refute an eating-related explanation of it, since it might be that such transient situational states do not interact with the hard-wired overlearned association between articulation and eating kinematics, or assimilation and contrast effects cancel out each other. However, the present evidence is also not supportive of an eating account. Thus, to enrich the conceptual arena regarding the driving mechanisms of the in-out effect, the second part will develop and test a novel possible explanation.

Part II: A Word-Morphologic Explanation of the In-Out Effect

In the very logic of the in-out effect, there is a core assumption that has not yet been questioned let alone tested empirically, namely that the effect is about inward and outward trajectories. All previous theorizing and all previous experiments in the literature on the in-out effect entailed the simple logic that inward words are preferred over outward words because the former *move* from the front to the back of the mouth (e.g., B_ _ K), while the latter *move* from the back to the front of the mouth (e.g., K _ _ B). That is, the undisputed assumption was that the front-to-back versus back-to-front trajectory is necessary for the in-out effect to occur. However, there are similarly plausible and even more parsimonious explanations. One is that the effect hinges on the identity of the starting consonants alone. It could be that inward words are preferred over outwards words because the former start at the front of the mouth (e.g., B _ _ _) and the latter start in the back of the mouth (e.g., K _ _ _). Likewise, it could hinge on the identity of the ending letter alone. It is possible that inward words are preferred over outward words because the former end in the back of the mouth (e.g., _ _ _K) and the latter end at the front of the mouth (e.g., _ _ _ B). These two much more parsimonious alternative explanations thus postulate that the in-out effect is driven by preferences for specific consonants in specific positions of a word, not by systematic relations between starting and ending consonants, that is, by certain articulatory *movements*. This account was tested in Part II.

To test the impact of specific consonants in specific positions of a word on evaluative ratings, stimuli were created whose consonant articulation spot and its position in the word were manipulated orthogonally. These stimuli only consisted of consonants that were articulated in the very front *or* the very back of the mouth and that were positioned at the beginning *or* the ending of a word. To avoid any possible confounds, instead of traditional word stimuli, words fragments were used. These word fragments only contained the respective front versus back consonants in starting or ending positions, followed or preceded by underscores. In the first experiment of Part II, we used stimuli that consisted of two consonants (front vs. back) that were positioned at the start and end of a word fragment (2-consonant fragments; e.g., M _ _ _ _ K, K _ _ _ _ M) to validate this new form of in-out stimuli. Conceptually, these stimuli resembled the letter pairs that were used in Topolinski and Boecker (2016a, Experiment 3), since they entailed a front consonant and a back consonant and therefore covered the entire front-to-back trajectory. Showing that these stimuli produce the in–out effect demonstrates that word fragments are a valid means for examining the in–out effect.

In the remaining experiments, we used minimized stimuli to account for the orthogonal contributions of position in the word and articulation spot, which were confounded in all previous operationalizations in the literature. Stimuli now either contained one consonant in the starting position (1-consonant fragments; e.g., M _ _ _ _, K _ _ _ _) or in the ending position (e.g., _ _ _ _ M, _ _ _ _ K), crucially, with these consonants either being articulated in the very front or the very back of the mouth. If preference effects evoked by 1-consonant stimuli that do not entail any inward or outward trajectory but merely activate a front or back articulation spot within the mouth are comparable with the in-out preferences of 2-consonant stimuli, this would question the role of oral inward movements. For the final two experiments, a full orthogonalization of position in the word and articulation spot was implemented for the first time. To do so, we extended the in-out stimuli used in Experiment 5 with the missing cells, namely 2-consonant fragments that featured front consonants (e.g., _ M _ _ _ _ B _) or back consonants (e.g., _ G _ _ _ _ K _) in starting *and* ending positions. Given the former evidence, this last operationalization should show whether the in-out effect depends on oral movements or can be pinned down to be a word-morphologic preference effect.

Data Treatment and a Priori Power Analysis

We report all exclusion of data (if any), all manipulations, and all measures for all experiments in this line of experiments. Data for all experiments and the preregistrations of Experiments 7 (https://osf.io/yvws2/?view_only=d194fa1e5939403d8dfb6b0bf17a4585) and 8 (https://osf.io/zwn4v/?view_only=9de659f5bc2c43b5a22450e0f715f2a5) will be made public upon publication. All stimuli can be found in the Appendix. Based on the results of Topolinski and Boecker (2016a) who already employed realizations of the in-out effect using only starting and ending consonants (e.g., the consonant pair BK vs. KB) but who did not test the present hypothesis, we assumed an effect size of $d_z = .45$ for the in-out effect. To detect the in-out effect with a power of .95, *G*Power* (Faul et al., 2007) yields $N_{required} = 55$. To assure that also weaker effects are detected, we arbitrarily set the samples sizes to $N = 100$ for Experiments 5 and 6. Based on the results of those two experiments, we decided to massively overpower Experiment 7 with $N = 300$, Experiment 8 (featuring a combined within design of Experiments 5 and 7) with $N = 150$, Experiment 9 with $N = 200$ and Experiment 10 (featuring a between design) with $N = 200$ to be able to find small effects. Experiments 5-9 were conducted on the campus of a German university and contain a disproportionately large number of young female participants. Experiment 10 was conducted online and replicates our findings on a sample that entailed more male and older participants.

Experiment 5: In-Out Effects with Word Fragments

In this first experiment of the present line of experiments, we first wanted to establish the basic in-out effect using the whole front-to-back vs. back-to-front trajectory with a minimal realization using only starting and ending consonants (e.g., B _ _ K vs. K _ _ B). This was done to a) validate the present stimulus set-up (using word fragments featuring underscores) and b) to gain an in-out effect for comparison reasons with the later experiments. Note that Topolinski and Boecker (2016a, Experiment 3) already used in-out stimulus material that featured only starting and ending consonants, but they actually used letter pairs (i.e., e.g., BK vs. KB).

Method

Participants. *N* = 100 (65 female, 35 male; M_{age} = 23, SD_{age} = 5) German-speaking participants were recruited via a local participant pool and were compensated with sweets for their participation in this task.

Materials. The two-letter fragments consisted of a starting consonant (front vs. back) and an ending consonant (front vs. back). Starting and ending consonants were separated by differing numbers of underscores (4, 5, 6, or 7 underscores) respectively. Consonants of two different articulation spots (in the very front and the very back) on the sagittal plane of the mouth were chosen (IPA, 1999). As front consonants, the labial consonants B, M, and P, and as back consonants, the velar and uvular consonants G, K, and R were selected. In German phonation (the language under investigation in this line of experiments), the consonant R as an ending letter is often pronounced as [ɐ], for instance in words ending in –er, which is a vowel instead of an R-sound. To ensure pronunciation as R-sound, an additional placeholder was added after the respective last letter, resulting in stimuli in the form of C[onsonant] _ _ _ _ _ _ C[onsonant] _. The procedure resulted in stimulus pools with letter stimuli starting with a front consonant and ending with a back consonant (inward fragments; e.g., B _ _ _ _ R _, M _ _ _ _ _ _ K _) and letter stimuli starting with a back consonant and ending with a front consonant (outward fragments; e.g., R _ _ _ _ B _, K _ _ _ _ _ _ M _). All possible combinations of front consonants and back consonants, separated by 4, 5, 6, or 7 underscores, were realized resulting in *N* = 72 stimuli in total.

Procedure. All six experiments of this line of experiments were PC-directed and presented each target stimulus for 1,000 ms. For each participant, 24 inward and outward fragments, respectively, were randomly drawn from the stimulus pool and sampled anew for each participant, resulting in 48 trials in total. Participants were instructed to read the letter stimuli silently in all experiments and to spontaneously rate their liking for the word fragments on a scale from 0 *(I do not like it at all)* to 10 *(I like it very much)*. Furthermore, they were told that this task was investigating basic reading processes and that they should not try to complete the word fragments (e.g., completing B _ _ K to BOOK) but should only rate their liking of the respective stimuli. After the ratings, participants provided demographic data and were dismissed.

Results and discussion

Again, mistyped responses or numbers that exceeded the scale were discarded (6 out of 4,796 trials; 0.13 %). The dependent measure of interest were the ratings of liking for inward and outward letter stimuli. Since the number of inserted underscores was only varied to ensure a greater variety of stimuli and no effect of length of stimuli was of interest, we collapsed over number of underscores.

Inward fragments (M = 5.33, SE = 0.10) received higher ratings of liking than outward fragments (M = 5.10, SE = 0.11), $t(99) = 4.50$, $p = .001$, $d_z = 0.45$, 95% CI [0.24, 0.65]. A classical item-based analysis (Clark, 1973) supported these results, additionally taking into account the impact of number of underscores, and found a main effect of articulation direction, $F_I(1, 72) = 7.06$, $p = .010$, $\eta_p^2 = .09$, 95% CI [0.01, 0.23], a main effect of number of underscores, $F_I(3, 72) = 2.89$, $p = .042$, $\eta_p^2 = .11$, 95% CI [0.00, 0.22], and no interaction between the two factors.

This effect established the present paradigm using word fragments that feature underscores, as we did indeed find an in-out effect when realizing the whole front-to-back vs. back-to-front trajectory. The next experiment used this paradigm to orthogonally gauge the respective possible contributions of the identity of only the starting and only the ending consonant.

Experiment 6: In-Out-Like Effects with Only One Letter

Here we tested the possible causal contributions to the in-out effect of only the starting and only the ending consonant by presenting word fragments that consisted of only a starting consonant (front vs. back) or an ending consonant (front vs. back). Thus, we investigated whether the mere activation of a front consonant at the beginning of a word fragment or a back consonant at the ending of a word fragment are sufficient to evoke in-out like preferences. This setup also allows to compare the results of 1-consonant fragments to those of the 2-consonant fragments used in Experiment 5, since the average of fragments that start with a front consonant and fragments that end with a back consonant would be concordant with inward fragments (regarding position in the word and articulation spot, *in-out concordant*) and the average of fragments that start with a back consonant and fragments that end with a front consonant would be concordant with outward fragments (*in-out discordant*). If the average of these in-out concordant fragments would be higher than the average of the in-out discordant fragments, we would have shown that one can evoke in-out like preferences without actual in-out stimuli. In turn, this would imply that position specific preferences are driving the in-out effect rather than inward wandering articulation patterns.

Method

Participants. N = 106 (71 female, 32 male, 3 diverse; M_{age} = 23, SD_{age} = 4) German-speaking participants participated in this task and were compensated with sweets.

Materials. Stimuli for the one-letter fragments consisted of a starting consonant (front vs. back) *or* an ending consonant (front vs. back), respectively, preceded or followed by 6, 7, 8, or 9 underscores. The same consonants for front and back articulation spots as in Experiment 5 were used. Again, an additional placeholder was added after the respective last consonant, for the same reasoning as described in Experiment 5, resulting in stimulus pools with stimuli in the form of C _ _ _ _ _ _ (starting either with a front or a back consonant; e.g., M _ _ _ _ _ _ vs. G _ _ _ _ _ _) and _ _ _ _ _ _ C _ (ending either with a front or a back consonant; e.g., _ _ _ _ _ _ M _ vs. _ _ _ _ _ _ G _), resulting in $N = 48$ stimuli in total.

Procedure. All stimuli were presented in randomized order, sampled anew for each participant. Using the same instructions as in Experiment 5, participants rated their liking of the word fragments on a scale from 0 *(I do not like it at all)* to 10 *(I like it very much)*. After completing the task, participants provided demographic data and were dismissed.

Results

Again, mistyped responses or numbers that exceeded that scale were discarded (3 out of 5,034 trials; 0.01 %). As done before, we collapsed over number of underscores and calculated means for the respective conditions. A 2 (Position in the word: starting, ending) X 2 (Articulation spot: front, back) repeated measures ANOVA was conducted and revealed a large main effect of position in the word, $F(1, 104) = 103.18$, $p < .001$, $\eta_p^2 = .50$, 95% CI [0.36, 0.60], in the way that word fragments that featured a starting consonant were preferred over word fragments that featured an ending consonant (statistics can be found in Table 5). This effect is conceptually irrelevant (see discussion). Also, a main effect of articulation spot emerged, $F(1, 104) = 12.01$, $p = .001$, $\eta_p^2 = .10$, 95% CI [0.02, 0.22]. Irrespective of position in the word fragment, front consonants ($M = 4.94$, $SE = 0.14$) were preferred over back consonants ($M = 4.65$, $SE = 0.14$), $t(104) = 3.47$, $p = .001$, $d_z = 0.34$, 95% CI [0.14, 0.53]. The interaction between position in the word and articulation spot was weak and not significant, $F(1, 104) = 2.24$, $p = .137$, $\eta_p^2 = .02$, 95% CI [0.00, 0.10].

Table 5

Conditional means (and standard errors) for preference ratings as a function of articulation spot (front, back) and position in the word (starting, ending) of 1-consonant fragments in Experiment 6, 7, and 8. Ratings were reported on a 0 to 10 scale.

Experiment	Front consonant Starting position	Front consonant Ending position	Back consonant Starting position	Back consonant Ending position
Experiment 6	6.00 (0.18)	3.88 (0.17)	5.62 (0.18)	3.68 (0.17)
Experiment 7	5.11 (0.09)	4.92 (0.09)	4.62 (0.09)	4.67 (0.08)
Experiment 8	4.84 (0.14)	4.76 (0.15)	4.35 (0.13)	4.55 (0.14)

An item-based analysis found a main effect of position in the word, $F_I(1, 8) = 1683.87$, $p < .001$, $\eta_p^2 = 1.00$, 95% CI [0.98, 1.00], and a main effect of articulation spot, $F_I(1, 8) = 12.18$, $p = .008$, $\eta_p^2 = .60$, 95% CI [0.07, 0.78], and an interaction between the two factors, $F_I(1, 8) = 7.59$, $p = .025$, $\eta_p^2 = .49$, 95% CI [0.00, 0.72], but no effect of number of underscores ($F_I(1, 8) = 0.75$).

Discussion

We find a general higher preference for front than for back consonants, irrespective of position in a word, a pattern that is not informative to the in-out effect. Rather, an interaction between articulation spot and position in word would be informative. While the subject-based analysis yielded such an interaction as non-significant, the item-based analysis yielded it significant. We argue that the weakness of this relevant interaction can be explained by the very strong main effect of the conceptually irrelevant factor of position in the word. This conceptually irrelevant effect that participants generally liked stimuli with consonants in starting than in ending positions surely is due to the strategy that participants tried to retrieve a matching meaningful word to inform their preference judgment. Such a strategy would of course run more successfully when a starting letter is given than when an ending letter is given (see the classical logic in Tversky & Kahneman, 1974). In the next experiment we tried to minimize such a possible word retrieval strategy to reduce the conceptually irrelevant impact of starting letter vs. ending letter given that might cloud the crucial interaction.

Experiment 7: In-Out-Like Effects with Only One Letter Revisited

A preregistered further experiment was conducted that should minimize word retrieval strategies and thus reduce the impact of the conceptually irrelevant factor of whether a starting or an ending letter was given. A placeholder was added at the very beginning of every word fragment. To illustrate this to the reader, the stimulus _ B _ _ _ allows a less likely successful search for an implied real word than the stimulus B _ _ _ _. It must be emphasized that due to this set-up what we call "starting" consonants are not really the initial starting letter of a target word anymore, but rather consonants early in the word. However, for convenience we will still call these starting consonants or consonants in the starting position.

Method

Participants. N = 301 (201 female, 95 male, 5 diverse; M_{age} = 23, SD_{age} = 4) German-speaking participants were approached on campus and were compensated with sweets for their participation in this study.

Materials and procedure. The 1-consonant fragments of Experiment 6 were used in this experiment. This time, a placeholder was added to the beginning of every letter stimulus, resulting in stimuli in the form of _ B _ _ _ _ _ for instance. Again, we presented all stimuli of the respective stimulus pools in randomized order, sampled anew for each participant, resulting in 48 trials. As before, participants rated their liking of the word fragments on a scale from 0 *(I do not like it at all)* to 10 *(I like it very much)*. After they finished the task, participants provided demographic data and were dismissed.

Results

Again, mistyped responses or numbers that exceeded that scale were discarded (20 out of 14,484 trials; 0.14 %). As done before, we collapsed over number of underscores and calculated means for the respective conditions. A 2 (Position in the word: starting, ending) X 2 (Articulation spot: front, back) repeated measures ANOVA revealed a main effect of articulation spot, $F(1, 300) = 39.47$, $p < .001$, $\eta_p^2 = .12$, 95% CI [0.06, 0.19], as front consonants (M = 5.02, SE = 0.08) were preferred over back consonants (M = 4.65, SE = 0.07), $t(300) = 6.28$, $p < .001$, $d_z = 0.36$, 95% CI [0.25, 0.48]. This time, no main effect of position in the word occurred, $F(1, 300) = 1.14$, indicating that the new set-up minimized word retrieval.

Crucially, an interaction between position in the word and articulation spot was found, $F(1, 300) = 16.74$, $p < .001$, $\eta_p^2 = .05$, 95% CI [0.01, 0.11]. In starting positions, front consonants were preferred over back consonants (statistics can be found in Table 5), $t(300) = 7.38$, $p < .001$, $d_z = 0.43$, 95% CI [0.31, 0.54]. In ending positions, front consonants were also preferred over ending back consonants, $t(300) = 3.78$, $p < .001$, $d_z = 0.22$, 95% CI [0.10, 0.33], however, with an effect of only half the size than in starting positions.

The interaction that the general preference for front consonants was stronger for starting than ending positions perfectly matches a pattern resembling the in-out effect. When we aggregate fragments compatible with an in-out pattern (fragments starting with front consonants and fragments ending with back consonants), these received higher liking ratings (M = 4.89, SE = 0.07) than fragments incompatible with an in-out pattern (fragments starting with back consonants and fragments ending with front consonants; M = 4.77, SE = 0.07), $t(300) = 4.09$, $p < .001$, $d_z = 0.24$, 95% CI [0.12, 0.35].

An item-based analysis confirmed these results, revealing a main effect of articulation spot, $F_I(1, 11) = 28.81$, $p < .001$, $\eta_p^2 = .72$, 95% CI [0.29, 0.84], and additionally a main effect of position in the word, $F_I(1, 11) = 7.88$, $p = .017$, $\eta_p^2 = 0.42$, 95% CI [0.01, 0.66], and an interaction between the two factors, $F_I(1, 11) = 7.23$, $p = .021$, $\eta_p^2 = .40$, 95% CI [0.01, 0.65]. Again, in-out concordant fragments (M = 4.89, SE = 0.07) descriptively received higher ratings of liking than in-out discordant fragments (M = 4.77, SE = 0.11), $t_I(22) = 0.92$, $p = .365$, 95% CI [-0.22, 0.60].

Discussion

Minimizing word-retrieval strategies in the methodological set-up reduced the main effect of position in a word and allowed the detection of an interaction between position in a word and articulation spot: Front consonants were generally preferred over back consonants, but this preference was stronger for starting than ending positions. This pattern mirrored an in-out-like effect, such as that in-out concordant fragments (fragments starting with front consonants and fragments ending with back consonants) were preferred over in-out discordant fragments (fragments starting with back consonants and fragments ending with front consonants). This means that in-out like preferences can be elicited by presenting only starting (front) or ending (back) consonants.

Experiment 8: In-Out-Like Effects with One and Two Letters Compared

To substantiate the present evidential value, both 1-consonant and 2-consonant fragments were tested in a preregistered within-subject design.

Method

Participants. $N = 150$ (104 female, 35 male; $M_{age} = 23$, $SD_{age} = 4$; demographic data was only collected for $N = 139$ participants) German-speaking participants were approached on campus and participated in the task for a compensation of sweets.

Materials and procedure. The 1-consonant fragments of Experiment 7 and the 2-consonant fragments of Experiment 5 were used in this experiment and were presented in separate blocks, with full randomization within a block and a counter-balancing of the order of the blocks, resulting in two blocks with 48 trials, respectively. The same instructions as in the previous experiments were being used and participants rated their liking of the word fragments on a scale from 0 *(I do not like it at all)* to 10 *(I like it very much)*. After they finished the task, participants provided demographic data and were dismissed.

Results

Mistyped responses or numbers that exceeded that scale were discarded (31 out of 14,324 trials; 0.22 %). Again, we collapsed over number of underscores and calculated means for the respective conditions. Because the two different stimulus types differed in their conceptual design, with 2-consonant fragments featuring only inward vs. outward fragments, but 1-consonant fragments featuring a 2 (Position) X 2 (Articulation spot) design, we tested the effects separately for these both stimulus types.

2-Consonant fragments. Inward fragments (*M* = 4.87, *SE* = 0.12) received higher ratings of liking than outward fragments (*M* = 4.71, *SE* = 0.12), $t(149) = 3.22$, $p = .002$, d_z = 0.26, 95% CI [0.10, 0.43], also in the item-based analysis, $t_I(70) = 2.14$, $p = .036$, $d = 0.25$, 95% CI [0.17, 0.49]. This replicates Experiment 6.

1-Consonant fragments. A 2 (Position in the word: starting, ending) X 2 (Articulation spot: front, back) repeated measures ANOVA revealed a main effect of articulation spot, $F(1, 149) = 23.52$, $p < .001$, $\eta_p^2 = .14$, 95% CI [0.05, 0.24], with front consonants being again preferred over back consonants, independently of their position. No main effect of position in the word occurred, $F(1,149) = 0.53$.

Again, an interaction between articulation spot and position in the word occurred, $F(1, 149) = 11.25$, $p = .001$, $\eta_p^2 = .07$, 95% CI [0.01, 0.16]. In starting positions, front consonants (statistics can be found in Table 5) were preferred over back consonants, $t(149) = 5.39$, $p < .001$, $d_z = 0.44$, 95% CI [0.27, 0.61]. Again, this general preference of front consonants was only half the size for ending positions, with ending front consonants being preferred over ending back consonants, $t(149) = 2.68$, $p = .008$, $d_z = 0.22$, 95% CI [0.06, 0.38], to a lesser but still significant degree. This pattern again mirrored the in-out effect pattern: Fragments compatible with an in-out pattern received higher liking ratings (*M* = 4.70, *SE* = 0.13) than fragments incompatible with an in-out pattern (*M* = 4.55, *SE* = 0.13), $t(149) = 3.36$, $p = .001$, $d_z = 0.27$, 95% CI [0.11, 0.44], thereby replicating the results of Experiment 7.

An item-based analysis confirmed these results, revealing a main effect of articulation spot, $F_I(1, 8) = 10.84$, $p = .011$, $\eta_p^2 = .58$, 95% CI [0.05, 0.77], and a marginal interaction between articulation spot and position in the word, $F_I(1, 8) = 3.88$, $p = .084$, $\eta_p^2 = .33$, 95% CI [0.00, 0.63], and no effect of position in the word ($F_I(1, 8) = 0.74$) or amount of underscores ($F_I(1, 8) = 0.22$). Fragments compatible with an in-out pattern (*M* = 4.69, *SE* = 0.04) received higher ratings of liking than fragments incompatible with an in-out pattern (*M* = 4.54, *SE* = 0.06), $t_I(22) = 2.20$, $p = .039$, $d = 0.46$, 95% CI [0.02, 0.88].

Discussion

Directly comparing the effect sizes of real in-out stimuli (the 2-consonant fragments) and stimuli whose starting and ending letters are compatible with an in-out pattern but do not actually feature a whole inward-outward trajectory (the 1-consonant fragments) we found both an in-out effect for 2-consonant fragments ($d_z = 0.26$) and an in-out-like effect for 1-consonant fragments ($d_z = 0.27$), with these effect sizes being quite similar to each other. These findings support the assumption that in-out like preferences can be produced without actual inward wandering articulation dynamics, which would require the activation of a starting and ending point of the oral trajectory, but through the mere activation of certain single articulation spots on certain positions of a word (fragment).

Experiment 9: Fully Crossing Articulation Spot and Position in a Word

A further experiment was designed in order to fully cross both relevant factors of articulation spot and position within a word. This time, we created 2-consonant fragments in which position in the word and articulation spot were manipulated orthogonally. So far, our evidence suggests that inward stimuli are preferred over outward stimuli because front consonants are preferred over back consonants and this preference is enhanced in starting positions of stimuli. As a last step, we investigated whether the preference for front consonants can also be extended to word stimuli that feature more than one consonant, wherefore we extended the design of Experiment 5 by adding 2-consonant fragments that featured front consonants (e.g., _ M _ _ _ _ B _) or back consonants (e.g., _ G _ _ _ _ K _) in starting *and* ending positions.

Method

Participants. N = 207 (67 female, 28 male; M_{age} = 23, SD_{age} = 4; due to a programming error, demographic data was only collected for N = 95 participants) German-speaking participants participated in the experiment and were compensated with sweets.

Materials and Procedure. The 2-consonant fragments from Experiment 8 that were concordant with inward and outward stimuli, respectively, were used. Additionally, in order to orthogonalize the experimental design, fragments were created that featured only front consonants (B, M, P) or back consonants (G, K, R), which resulted in N = 30 stimuli for each condition. As before, all stimuli started and ended with a placeholder and no consonant reoccurred within one stimulus. Thus, our stimulus pool featured stimuli that started with a front consonant and ended with a back consonant (inward fragments; e.g., _ B _ _ _ _ K _), started and ended with a front consonant (front fragments; e.g., _ B _ _ _ _ M _), started with a back and ended with a front consonant (outward fragments; e.g.; _ G _ _ _ _ P _), and started and ended with a back consonant (back fragments; e.g., _ K _ _ _ _ G _). N = 24 stimuli of each condition were randomly drawn and presented in randomized order, resulting in a total of 96 trials. As done before, participants rated their liking of the word fragments on a scale from 0 *(I do not like it at all)* to 10 *(I like it very much)*. After they finished the task, participants provided demographic data and were dismissed.

Results

Mistyped responses or numbers that exceeded that scale were discarded (21 out of 19,828 trials; 0.01 %) and we collapsed over number of underscores and calculated means for the respective conditions. A 2 (Starting with front vs. back consonant) X 2 (Ending with front vs. back consonant) repeated measures ANOVA revealed a main effect of starting, $F(1, 206) = 32.96$, $p < .001$, $\eta_p^2 = .14$, 95% CI [0.06, 0.23], with front consonants being preferred over back consonants in starting positions (statistics can be found in Table 6). Additionally, a main effect of ending occurred, $F(1, 206) = 13.05$, $p < .001$, $\eta_p^2 = .06$, 95% CI [0.01, 0.13], as front consonants were also preferred over back consonants in ending positions. Crucially, the main effect for starting positions was larger than the main effect for ending positions, $t(206) = 2.29$, $p = .023$, $d_z = 0.16$, 95% CI [0.02, 0.30], that is, the preference for front over back consonants was double as large ($\eta_p^2 = .14$) than the front preference in ending positions ($\eta_p^2 = .06$).

Table 6

Conditional means (and standard errors) for preference ratings as a function of starting position (front consonant, back consonant) and ending position (front consonant, back consonant) of 2-consonant fragments in Experiment 9. Ratings were reported on a 0 to 10 scale.

Starting front Ending front	Starting front Ending back	Ending back Starting front	Ending back Ending back
4.56 (0.11)	4.54 (0.11)	4.44 (0.10)	4.20 (0.10)

Additionally, we found a conceptually irrelevant interaction, $F(1, 206) = 18.15$, $p < .001$, $\eta_p^2 = .08$, 95% CI [0.02, 0.16], in the way that descriptively the front-over-back preference for ending positions was stronger if the stimulus started with a front consonant. This interaction was not replicated in the following experiment.

Discussion

We again find a general preference for front over back consonants, for both starting and ending positions; but this preference was larger for starting than for ending positions. This pattern can be seen as a viable explanation of the in-out effect: Inward words, that is, words that start with front and end with back consonants, perfectly fall into this pattern; outward words, that is, words that start with back consonants and end with front consonants, do not.

Experiment 10: Joint examination of eating-related and word-morphologic manipulations

A final experiment was conducted to jointly manipulate eating-related states (Part I) and word-morphology (Part II). To do so, we again employed the video disgust induction (Experiments 1 and 4) and employed the 2-consonant fragments from Experiment 9. To increase the likelihood that eating-related states would have an influence, we changed the framing and dependent measure to a food context (cf., Rossi et al., 2017; Topolinski & Boecker, 2016b) by instructing participants that the stimuli they would receive would be names for dishes, and they are to rate the palatability of these dishes.

Method

Participants. N = 203 (75 female, 126 male, 1 other; M_{age} = 40, SD_{age} = 14; demographic data was not recorded for one participant) German-speaking participants were recruited via the online platform *Clickworkers* and received €1 as compensation.

Materials and Procedure. As described, the video disgust induction of Experiment 1 and 4 was used. However, to increase experimental efficacy, we decided to present only two (disgusting vs. neutral) videos. After participants had seen a video, they evaluated 48 word fragments. Then, this procedure was repeated, using the second video and different word fragments. The stimulus pool of Experiment 9 was used. Again, n = 24 stimuli of each condition were randomly drawn and presented in randomized order, resulting in a total of 96 trials.

The stimuli were labelled as names of dishes, and the dependent variable was *"How palatable is this dish?"* from 0 (*Not at all palatable)* to 10 *(Very palatable)*. After participants had finished the task, we assessed how disgusted they were by the videos on a scale from 0 (*Not at all disgusted*) to 10 (*Very disgusted*) as well as their current oral intentions on a five-point scale ranging from 1 (*swallowing*) to 5 (*spitting*) as done in Experiment 1. Afterwards, participants provided demographic data and were dismissed.

Results

The check as well as the manipulation validation were significant. Participants in the disgust condition felt more disgusted by the videos (M = 7.92, SD = 3.08) than participants in the neutral condition (M = 0.43, SD = 1.18), $t(200) = 22.58$, $p < .001$, d = 3.18, 95% CI [2.76, 3.59] and reported higher oral intentions of spitting in the disgust condition (M = 3.97, SD = 0.89) compared to participants in the neutral condition (M = 2.26, SD = 0.90), $t(200) = 13.65$, $p < .001$, d = 1.92, 95% CI [1.59, 2.25].

Mean palatability ratings were entered into a 2 (Starting with front vs. back consonant; within-subjects) X 2 (Ending with front vs. back consonant; within-subjects) X 2 (Disgust vs. neutral movies; between-subjects) ANOVA (statistics can be found in Table 7). As in Experiment 9, we observed a main effect of starting position, $F(1, 201) = 24.98$, $p < .001$, η_p^2 = .11, 95% CI [0.04, 0.19], with front consonants being preferred over back consonants in starting positions. Additionally, a main effect of ending position occurred, $F(1, 201) = 11.81$, $p < .001$, η_p^2 = .06, 95% CI [0.01, 0.13], with front consonants being also preferred over back consonants in ending positions. There was no interaction between starting position and ending position, $F(1, 201) = 0.39$, $p = .534$. Again, the main effect of front preference was, at least descriptively, stronger for starting (η_p^2 = .11) than for ending position (η_p^2 = .06), $t(202)$ = 1.73, $p = .085$, d_z = 0.12, 95% CI [-0.02, 0.26].

Table 7

Conditional means (and standard errors) for preference ratings as a function of starting position (front consonant, back consonant) and ending position (front consonant, back consonant) of 2-consonant fragments in Experiment 10 for stimuli that were labelled as dishes and presented after neutral versus disgusting videos (between-participants). Ratings were reported on a 0 to 10 scale.

Emotion condition	Starting front Ending front	Starting front Ending back	Ending back Starting front	Ending back Ending back

Neutral	5.09 (0.15)	5.00 (0.15)	4.96 (0.15)	4.83 (0.15)
Disgust	3.86 (0.17)	3.81 (0.16)	3.73 (0.16)	3.66 (0.16)

Crucially, none of these effects interacted with disgust, all $F(1, 201) < 1$, indicating that disgust did not moderate any of the front preference effects. Instead, we observe a main effect of disgust, $F(1, 201) = 30.62$, $p < .001$, $\eta_p^2 = .13$, 95% CI [0.06, 0.22], indicating that participants in the disgust condition rated all word fragments as less palatable than participants in the neutral condition, which finding might be seen as an additional confirmation that the disgust manipulation succeeded in reducing participants' eating motivation.

Discussion

Connecting the two lines of research in this paper, regarding eating-related internal states (Part I) and word-morphologic effects (Part II), we again found the word-morphologic pattern of an enhanced front-over-back consonants preference for starting over ending positions. Despite a positive manipulation check and a framing of food-related ratings, the disgust manipulation did not at all modulate the articulation-based effect.

General Discussion

In two lines of experiments, we explored the driving mechanisms of the in-out effect (Topolinski et al., 2014). In the first line of experiments, we found no evidence that the in-out effect is modulated by eating-related internal states. Although we went to great lengths methodologically and logistically (e.g., food deprivation) and used established methods with rigorous manipulation checks and large sample sizes, no interactions occurred, neither in an assimilative fashion (as in Godinho et al., 2019; Topolinski et al., 2017; who manipulated subject-external denoted meaning) nor in a contrastive fashion. Thus, we could not find supporting evidence for an eating-related explanation. As already said in the interim conclusion, this null evidence does not ultimately speak against an eating-related explanation, but it adds to the literature the fact of lacking support despite rigorous tests with high statistical power.

In the second line of experiments, we found a word-morphological effect that we introduce as a novel possible explanation of the in-out effect. Consonants articulated in the front of the mouth were generally preferred over consonants articulated in the back of the mouth, and this preference was enhanced in starting positions of a word. Since “classic” inward words start with consonants that are articulated in the front of the mouth while outward words do not, it is possible that the in-out effect relies on this combination of the general preference for front over back consonants and a position primacy effect. In the following, we will first discuss the possible psychological background of this word-morphological effect and derive novel predictions from the within-word primacy effect that might stimulate future research in areas of language-embodiment and psycholinguistics. Then, we explain why the present evidence speaks against the previously proposed fluency-explanation of the in-out effect.

Preference for front consonants and within-word primacy

The word-morphological evidence from Part II suggests two necessary and sufficient conditions for the in-out effect, two causal antecedents that are actually themselves not related to each other but jointly elicit the in-out effect as a product of their coincidence.

Front consonant preference

First, consonants that are produced in the front of the mouth are generally preferred over those produced in the back of the mouth. The ultimate cause of this front-consonant preference cannot be explored in this paper but might have its roots in early language acquisition. All infants acquire their mother tongue in the same chronological order (Höhle, 2010). Beginning in the 20^{th} week, infants start to articulate distinct phonemes that form into babbling of sequences that consist of consonants and vowels. Ingram (1974) described the tendency that in baby talk, the first consonant is located in a more anterior (front) place of articulation then the second, which is referred to as *fronting*. Consonants that are articulated in the front of the mouth (e.g., labial consonants such as B, M, and P) are among the first consonants infants articulate (Oller, Wieman, Doyle, & Ross, 1975), whereas A is the first vowel being articulated (Zimmer, 1988). A preference of labial (articulated in the very front of the mouth) over coronal consonants (articulated with the flexible part of the tongue) can still be found in adult speech, which underlines the fundamental importance of this pattern within speech (MacNeilage, Davis, Kinney, & Matyear, 2000). For this, basic biomechanical properties of sound production might play a causal role, such as motor effort (Kirchner, 2013) in the sense that front consonants are motorically easier to produce than back consonants.

Within-word primacy and implications for future research

The second causal ingredient of the in-out effect is completely independent of that front-consonant preference. Within-word primacy is the observation that the initial letter or the beginning of a word matters more. A closer examination of the existing literature shows that within-word primacy is also evident in other domains, although this earlier research was not explicitly targeted at within-word primacy. For instance, the first letter of a word is the most important determinant in word identification during reading (Gibson & Levin, 1975; Posnansky and Rayner, I977; Rayner & Hagelberg, 1975) and is prioritized in lexical access (Lima & Inhoff, 1985). Also, the name letter effect, that is, people's preference for letters contained in their own name, is most pronounced for name initials (Nuttin, 1985; Hodson & Olson, 2005). To name another example, it is the voicedness of the onset of a name, that is, of the initial letter, that determines gender intuitions about names (Slepian & Galinsky, 2016). On the other side, it has been shown that when employing more than one inward-outward movement in a word, a recency effect of the last articulation direction occurs (Topolinski & Bakhtiari, 2016).

Going beyond the specific significance as a possible driving mechanism of the in-out effect, the present word-morphological pattern opens the case that any (superficial) psycholinguistic property of a word has a stronger psychological impact when it occurs in the beginning of a word. This can be tested for any kind of effects, embodied effects such as vowels activating the smiling muscle (Rummer, Schweppe, Schlegelmilch, & Grice, 2014), or other sound-symbolic effects. In the latter case, Klink and Wu (2014) have already shown that sound-symbolism effects are stronger in the first than in the second syllable of a word.

The arguably most interesting case in this vein is pronounceability (Song & Schwarz, 2009). Easy-to-pronounce names elicit positive attitudes towards the name bearer (e.g., Alter & Oppenheimer, 2008; Silva, Chrobot, Newman, Schwarz, & Topolinski, 2017; Zürn & Topolinski, 2017). The present account would predict that this fluency would have greater impact when occurring in the beginning of a word. That is, an easy-difficult sequence of syllables in a word should be preferred over a difficult-easy sequence, although the overall fluency of the whole word is equal. This, however, runs counter the notion that individuals take pleasure in experiencing an initial cognitive difficulty that is instantly followed by mental ease (e.g., Topolinski & Reber, 2010), such as in sense making in surprise (Maguire, Maguire, & Keane, 2011) or cognitively mastering the initial incongruence when reading a joke (Forabosco, 1992). Future research might test these sequential effects of fluency.

Implications for a frequentist-fluency explanation of the in-out effect

Besides the eating-related embodied explanation of the in-out effect featured in most of the published literature, there are two papers that explore a *processing fluency account* (e.g., Alter & Oppenheimer, 2008; Reber, Schwarz, & Winkielman, 2004; Unkelbach, 2007) of the in-out effect. Bakhtiari et al. (2016) showed that inward letter strings are rated as being easier to pronounce than outward letter strings, and that this pronunciation advantage partially (but not fully) mediates the impact of articulation direction on preference. They argue that this fluency advantage stems from the ecological fact that inward trajectories are more common in natural language than outward trajectories, and higher ecological frequency increases ease of processing/fluency (Balota & Chumbley, 1985; Ellis, 2002). To support this argument, they provide a corpus analysis with a corpus of German words, which shows that the front consonants under investigation are more frequent at the starting (23.30%) than at the ending position of a word (5.50%), and back consonants are more frequent at the ending (20.30%) than at the starting position of a word (18.70%; Bakhtiari et al., 2016, p. 112). Further supporting such a frequentist fluency account, Körner, Bakhtiari, and Topolinski (2019) showed that a massive training of outward (vs. inward) articulation trajectories could reverse (vs. strengthen) the in-out effect.

The present evidence provides two effects that speak against such a frequentist explanation. First, we find a general preference for front over back consonants. A frequentist account would explain this with the seeming fact that front consonants are more frequent in language than back consonants. This, however, is not the case for the consonants used in our experiments, with the front consonants B, M, and P having an aggregated frequency of 5.21% in the German language, and the back consonants G, K, R an aggregated frequency of 11.22% (Beutelspacher, 2005, p. 10), thus being twice as frequent.

Second, the present Experiments 7–9, being the first to assess preference for certain consonants in starting and ending positions separately, found this front-over-back consonant preference for both starting and ending positions (although attenuated for ending positions). A frequentist approach would derive that this must be due to the circumstance that front consonants are more common than back consonants at both the starting and ending positions of natural words. However, the corpus analysis provided by Bakhtiari et al. (2016) documents that at the starting position of natural German words, front consonants are indeed more frequent (23.30%) than back consonants (18.70%), but at the ending position, back consonants occur substantially more often (20.30%) than front consonants (5.50%; Bakhtiari et al., 2016, p. 112). Thus, a frequentist explanation would expect a greater preference for back consonants at the end of words, while we find the opposite effect. In sum, these novel findings speak against a frequentist fluency explanation, but more research is needed to reconcile these different approaches.

Finally, regarding the locus of the in-out effect, our present findings could also explain why oral interference did not attenuate the in-out effect in previous research. Under oral motor-interference (e.g., when chewing gum or whispering a task-irrelevant word), the oral muscles are occupied with motor noise and thus cannot subvocally simulate the articulation of inward and outward words (see Topolinski, 2012; but also see Westerman, Klin, & Lanska, 2015). In such a state, fluency variations in articulation are less likely to be experienced. Lindau and Topolinski (2018) employed such oral motor-interference tasks and found no impact on the in-out effect. This suggests that the in-out effect does not depend on oral muscle activities but rather constitutes a lifelong-learned preference for front consonants.

Conclusion

The present experiments employed rigorous methods and highly powered designs resulting in successfully manipulated eating-related internal states of participants but still found no interaction with the in-out effect. Thus, we found no support for an eating-related explanation of the in-out effect. Furthermore, an alternative word-morphologic explanation is tested and supported, stating that the in-out effect might be partially produced by a general preference for front over back consonants that is enhanced for starting compared to ending positions in a word. The present evidence also directly speaks against a fluency or frequentist explanation of the in-out effect.

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APPENDIX

Verbal Stimulus Pools

2-consonant stimuli used in Experiments 5, 8, and 9

Inward fragments:

B _ _ _ _ G _, P _ _ _ _ G _, M _ _ _ _ G _, B _ _ _ _ _ G _, P _ _ _ _ _ G _, M _ _ _ _ _ G _, B _ _ _ _ _ _ G _, P _ _ _ _ _ _ G _, M _ _ _ _ _ _ G _, B _ _ _ _ _ _ _ G _, P _ _ _ _ _ _ _ G _, M _ _ _ _ _ _ _ G _, B _ _ _ _ K _, P _ _ _ _ K _, M _ _ _ _ K _, B _ _ _ _ _ K _, P _ _ _ _ _ K _, M _ _ _ _ _ K _, B _ _ _ _ _ _ K _, P _ _ _ _ _ _ K _, M _ _ _ _ _ _ K _, B _ _ _ _ _ _ _ K _, P _ _ _ _ _ _ _ K _, M _ _ _ _ _ _ _ K _, B _ _ _ _ R _, P _ _ _ _ R _, M _ _ _ _ R _, B _ _ _ _ _ R _, P _ _ _ _ _ R _, M _ _ _ _ _ R _, B _ _ _ _ _ _ R _, P _ _ _ _ _ _ R _, M _ _ _ _ _ _ R _, B _ _ _ _ _ _ _ R _, P _ _ _ _ _ _ _ R _, M _ _ _ _ _ _ _ R _.

Outward fragments:

G _ _ _ _ B _, K _ _ _ _ B _, R _ _ _ _ B _, G _ _ _ _ _ B _, K _ _ _ _ _ B _, R _ _ _ _ _ B _, G _ _ _ _ _ _ B _, K _ _ _ _ _ _ B _, R _ _ _ _ _ _ B _, G _ _ _ _ _ _ _ B _, K _ _ _ _ _ _ _ B _, R _ _ _ _ _ _ _ B _, G _ _ _ _ M _, K _ _ _ _ M _, R _ _ _ _ M _, G _ _ _ _ _ M _, K _ _ _ _ _ M _, R _ _ _ _ _ M _, G _ _ _ _ _ _ M _, K _ _ _ _ _ _ M _, R _ _ _ _ _ _ M _, G _ _ _ _ _ _ _ M _, K _ _ _ _ _ _ _ M _, R _ _ _ _ _ _ _ M _, G _ _ _ _ P _, K _ _ _ _ P _, R _ _ _ _ P _, G _ _ _ _ _ P _, K _ _ _ _ _ P _, R _ _ _ _ _ P _, G _ _ _ _ _ _ P _, K _ _ _ _ _ _ P _, R _ _ _ _ _ _ P _, G _ _ _ _ _ _ _ P _, K _ _ _ _ _ _ _ P _, R _ _ _ _ _ _ _ P _.

1-consonant stimuli used in Experiments 6, 7, and 8

Fragments starting with a front consonant (for Experiments 7 and 8, an additional placeholder was added at the very beginning of each word fragment):

B _ _ _ _ _ _, P _ _ _ _ _ _, M _ _ _ _ _ _, B _ _ _ _ _ _ _, P _ _ _ _ _ _ _, M _ _ _ _ _ _ _, B _ _ _ _ _ _ _ _, P _ _ _ _ _ _ _ _, M _ _ _ _ _ _ _ _, B _ _ _ _ _ _ _ _ _, P _ _ _ _ _ _ _ _ _, M _ _ _ _ _ _ _ _ _.

Fragments starting with a back consonant (for Experiments 7 and 8, an additional placeholder was added at the very beginning of each word fragment):

G _ _ _ _ _ _, K _ _ _ _ _ _, R _ _ _ _ _ _, G _ _ _ _ _ _ _, K _ _ _ _ _ _ _, R _ _ _ _ _ _ _, G _ _ _ _ _ _ _ _, K _ _ _ _ _ _ _ _, R _ _ _ _ _ _ _ _, G _ _ _ _ _ _ _ _ _, K _ _ _ _ _ _ _ _ _, R _ _ _ _ _ _ _ _ _.

Fragments ending with a front consonant:

_ _ _ _ _ _ B _, _ _ _ _ _ _ P _, _ _ _ _ _ _ M _, _ _ _ _ _ _ _ B _, _ _ _ _ _ _ _ P _, _ _ _ _ _ _ _ M _, _ _ _ _ _ _ _ _ B _, _ _ _ _ _ _ _ _ P _, _ _ _ _ _ _ _ _ M _, _ _ _ _ _ _ _ _ _ B _, _ _ _ _ _ _ _ _ _ P _, _ _ _ _ _ _ _ _ _ M _.

Fragments ending with a back consonant:

_ _ _ _ _ _ G _, _ _ _ _ _ _ K _, _ _ _ _ _ _ R _, _ _ _ _ _ _ _ G _, _ _ _ _ _ _ _ K _, _ _ _ _ _ _ _ R _, _ _ _ _ _ _ _ _ G _, _ _ _ _ _ _ _ _ K _, _ _ _ _ _ _ _ _ R _, _ _ _ _ _ _ _ _ _ G _, _ _ _ _ _ _ _ _ _ K _, _ _ _ _ _ _ _ _ _ R _.

2-consonant stimuli used in Experiment 9 and 10

Front fragments:

_ B _ _ _ _ P _, _ B _ _ _ _ M _, _ P _ _ _ _ M _, _ P _ _ _ _ B _, _ M _ _ _ _ P _, _ M _ _ _ _ B _, _ B _ _ _ _ _ P _, _ B _ _ _ _ _ M _, _ P _ _ _ _ _ M _, _ P _ _ _ _ _ B _, _ M _ _ _ _ _ P _, _ M _ _ _ _ _ B _, _ B _ _ _ _ _ _ P _, _ B _ _ _ _ _ _ M _, _ P _ _ _ _ _ _ M _, _ P _ _ _ _ _ _ B _, _ M _ _ _ _ _ _ P _, _ M _ _ _ _ _ _ B _, _ B _ _ _ _ _ _ _ P _, _ B _ _ _ _ _ _ _ M _, _ P _ _ _ _ _ _ _ M _, _ P _ _ _ _ _ _ _ B _, _ M _ _ _ _ _ _ _ P _, _ M _ _ _ _ _ _ _ B _, _ B _

_ _ _ _ _ _ _ P _, _ B _ _ _ _ _ _ _ _ M _, _ P _ _ _ _ _ _ _ _ M _, _ P _ _ _ _ _ _ _ _ B _, _ M _ _ _ _ _ _ _ _ P _, _ M _ _ _ _ _ _ _ _ B _.

Back fragments:

_ G _ _ _ _ R _, _ G _ _ _ _ K _, _ R _ _ _ _ K _, _ R _ _ _ _ G _, _ K _ _ _ _ R _, _ K _ _ _ _ G _, _ G _ _ _ _ _ R _, _ G _ _ _ _ _ K _, _ R _ _ _ _ _ K _, _ R _ _ _ _ _ G _, _ K _ _ _ _ _ R _, _ K _ _ _ _ _ G _, _ G _ _ _ _ _ _ R _, _ G _ _ _ _ _ _ K _, _ R _ _ _ _ _ _ K _, _ R _ _ _ _ _ _ G _, _ K _ _ _ _ _ _ R _, _ K _ _ _ _ _ _ G _, _ G _ _ _ _ _ _ _ R _

, _ G _ _ _ _ _ _ _ K _, _ R _ _ _ _ _ _ _ K _, _ R _ _ _ _ _ _ _ G _, _ K _ _ _ _ _ _ _ R _, _ K _ _ _ _ _ _ _ G _, _ G _ _ _ _ _ _ _ _ R _, _ G _ _ _ _ _ _ _ _ K _, _ R _ _ _ _ _ _ _ _ K _, _ R _ _ _ _ _ _ _ _ G _, _ K _ _ _ _ _ _ _ _ R _, _ K _ _ _ _ _ _ _ _ G _.