Robust and Replicable, but also Inexplicable?

Articulation Dynamics and their Effects on (Evaluative) Judgments

Moritz Ingendahl

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Supervisors:

Prof. Dr. Michaela Wänke

Prof. Dr. Tobias Vogel

Dean of the Faculty of Social Sciences:

Prof. Dr. Michael Diehl

Academic Director of the CDSS:

Prof. Dr. Thomas Gschwend

Thesis Evaluators:

Prof. Dr. Herbert Bless

Prof. Dr. Hans Alves

Examination Committee:

Prof. Dr. Michaela Wänke

Prof. Dr. Tobias Vogel

Prof. Dr. Herbert Bless

Prof. Dr. Hans Alves

Thesis Defense: 20.05.2022

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Abstract

A flourishing research area located between social and cognitive psychology investigates the influence of articulation dynamics on different judgments and decisions. The most prominent finding from this research area is the articulatory in-out effect – stimuli with inward-wandering consonant sequences (e.g., BODIKA) are liked more than those with outward-wandering consonant sequences (e.g., KODIBA). This in-out effect has proven robust across languages and contexts, yet the underlying processes are still debated. In the present dissertation, I provide an overview of the in-out effect and its boundary conditions. Furthermore, I elaborate on the three theoretical accounts that are currently discussed to explain the effect: oral approach/avoidance, consonant preferences, and fluency. I summarize and critically reflect on empirical work conducted to test these accounts. Overall, the empirical studies show that none of the three accounts sufficiently explain the in-out effect, suggesting that our understanding of the phenomenon is still poor. I discuss a general framework for further developing the research field on articulation dynamics.

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Articles

This cumulative thesis is based on five articles published in peer-reviewed journals and one manuscript currently in preparation. The main text provides an overview and encompassing framework for these papers, whereas statistical and empirical details are found in the original articles appended to this thesis.

Ingendahl, M., & Vogel, T. (2022). Choosing a brand name that's "in" – disgust sensitivity, preference for intuition, and the articulatory in-out effect. *Personality and Individual Differences*, *185*, 111276. https://doi.org/10.1016/j.paid.2021.111276

Ingendahl, M., Maschmann, I. T., Embs, N. M., Maulbetsch, A., Vogel, T., & Wänke, M. (2022). *Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.* Manuscript in preparation.

Ingendahl, M., & Vogel, T. (2022). The articulatory in-out effect: Driven by consonant preferences? *Journal of Personality and Social Psychology*, *122*(2), e1–e10. https://doi.org/10.1037/pspa0000276

Ingendahl, M., Vogel, T., & Wänke, M. (2022). The Articulatory In-Out Effect: Driven by Articulation Fluency? *Journal of Experimental Social Psychology*, *99*, 104273. https://doi.org/10.1016/j.jesp.2021.104273

Ingendahl, M., Schöne, T., Wänke, M., & Vogel, T. (2021). Fluency in the in-out effect: The role of structural mere exposure effects. *Journal of Experimental Social Psychology*, *92*, 104079. https://doi.org/https://doi.org/10.1016/j.jesp.2020.104079

Ingendahl, M., Vogel, T., & Topolinski, S. (2022). The articulatory in-out effect: replicable, but inexplicable. *Trends in Cognitive Sciences*, *26*(1), 8–10. https://doi.org/https://doi.org/10.1016/j.tics.2021.10.008

"Man acts as though he were the shaper and master of language, while in fact language remains the master of man." – Martin Heidegger

Finding a good name is a difficult task – not only when naming our children but also when naming new brands or products. Many unfortunate examples show how the wrong name can have detrimental consequences for a brand's success. For instance, the Ford Pinto had a hard time when introduced in the Brazilian market, where "Pinto" is also used to describe male genitals (Sunshine, 2012). Presumably, Puffs, facial tissues produced by Procter & Gamble, also raised some eyebrows when the brand first appeared in German drug stores. Similar problems might have occurred for the "Mist Stick", a curling iron by Clairol. In general, brand names have a tremendous impact on a brand's market success (Kohli & LaBahn, 1997), making brand name generation a top priority for marketing companies. Thus, how should one come up with a new brand name?

In the abovementioned examples, the main problem is that the name already contains a specific (negative) meaning (Pinto, Puffs) or that it bears phonological similarity with something negative (Mist Stick ~ "Miststück", a German insult). This problem can be avoided by thorough cross-cultural market research. However, beyond such obvious semantic associations, recent research has identified even more subtle influences on how a brand name is conceived. For instance, should IKEA name a new cupboard MÄLIGÖ or GÄLIMÖ? Both names sound highly similar and, in fact, even contain the same letters and phonemes, suggesting that it should not matter which of the two names IKEA chooses. Yet, it matters, and on the following pages, I will discuss why.

In this dissertation, I will provide an overview of one subtle yet powerful influence on the liking of brands, products, names, or words – the articulation dynamic and the related phenomenon of the articulatory in-out effect (Topolinski et al., 2014). In the next section, I will first introduce the broader framework of the in-out effect, the connection between language, sounds, and attitudes. Afterward, I will explain the in-out effect, how it is commonly studied, and its boundary conditions.

Language, Sounds, and Attitudes

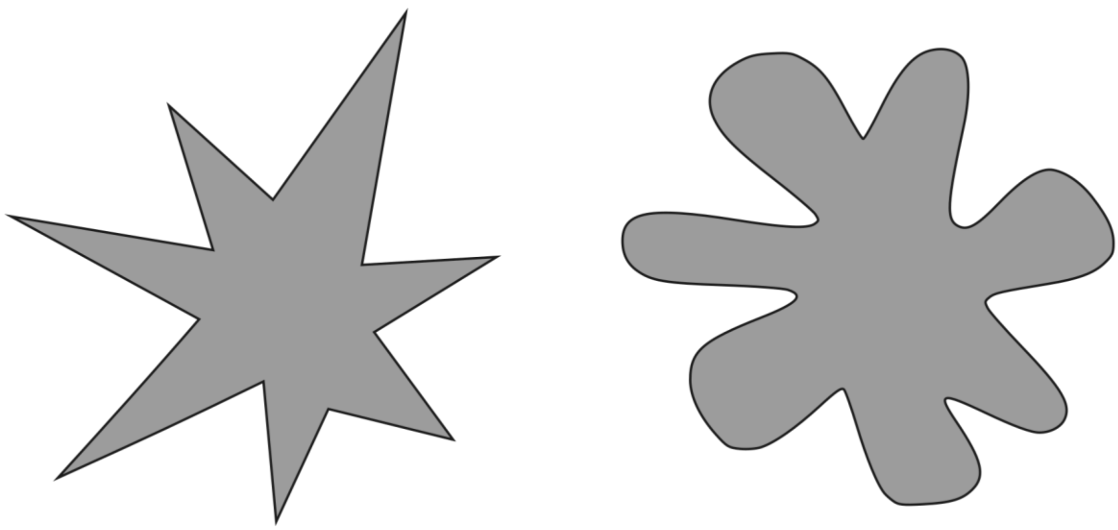
One of the most debated questions in linguistics is whether there is an inherent relationship between sounds and meaning. According to the “father of modern linguistics” Ferdinand de Saussure, and his *arbitrariness* hypothesis, there is no direct connection between a specific sound pattern and a concept (De Saussure, 1916). For instance, the word *dog* only refers to an animal with four legs, fear of vacuum cleaners, and an insatiable desire for belly rubs because society has agreed on that, but not because of any inherent connection between the sound *dog* and the concept *dog*. This assumed neutrality of phonemes as the building block of human language is a key difference from vocal communication among other species (Yu et al., 2021a).

However, this strong assumption of arbitrariness is questioned by the large body of literature on sound symbolism. Sound symbolism refers to an “association between phonemes and particular perceptual and/or semantic elements” (Sidhu & Pexman, 2018, p. 1619). As a well-known case for sound symbolism, take a look at Figures 1a and 1b. Let us assume you were tasked to match these two figures to one of the following words – *Bouba* and *Kiki*. Which name would you assign to which figure? Across languages and cultures (Ćwiek et al., 2022), people are more likely to assign *Bouba* to rounded shapes and *Kiki* to spiked shapes, a phenomenon referred to as Bouba/Kiki effect or Maluma/Takete effect (Köhler, 1929). A similar and prominent phenomenon is the Mil/Mal effect (Sapir, 1929): Individuals tend to associate high or front vowels (such as in Mil) with small objects and back or low vowels (such as in Mal) with large objects (Spence, 2011).

Figure 1

Example Shapes for Studying the Bouba/Kiki Effect

a) b)



Note. (Dunn, 2004). CC BY-SA 3.0.

Since these first seminal studies, many further interesting connections between sound and meaning have been discovered, and sound symbolism has grown into a substantial research field (for reviews, see Sidhu & Pexman, 2018; Svantesson, 2017). The most prominent classification of sound symbolism (Hinton et al., 1994) divides the different phenomena into *synesthetic* sound symbolism where certain phonemes represent visual/proprioceptive/tactile properties of objects (e.g., size or shape), and *conventional* sound symbolism where certain phonemes are associated with specific meaning (e.g., [gl] in glitter/glow/etc. are associated with light in English language)[1]. Explanations for sound

[1] Additional categories are corporeal sound symbolism where sounds express the internal state of the speaker (e.g., "ouch" as an exclamation of pain) and imitative sound symbolism or

symbolism reach from statistical co-occurrences between sounds and meaning (e.g., small things often resonate with higher frequency in our environment, explaining the vowel-size association in the Mil/Mal effect), to shared properties of phonemes and associated stimuli (e.g., the oral cavity is smaller when articulating front vowels) (Sidhu & Pexman, 2018; Spence, 2011).

In the last decades, sound symbolism has also found its way into consumer and marketing research (Coulter & Coulter, 2010; Klink, 2000; Lowrey & Shrum, 2007; Yorkston & Menon, 2004). Consumers infer product information from brand names. For instance, front vowels ([i], [e]) are typically associated with attributes such as smallness, speed, sharpness, and prettiness, whereas back vowels ([a], [o], [u]) are associated with attributes such as large size, weight, or chewiness (Klink, 2000). Most of the studies in sound symbolism have focused on the role of vowels and neglected the influence of consonants (Klink & Wu, 2014; Yaran Ögel & Bayraktaroglu, 2020). Yet, some studies indicate that, for instance, fricatives (e.g., [f], [s], versus stop consonants such as [p], [k]) are associated with attributes such as smallness, femininity, and lightness (Klink, 2000; Klink & Wu, 2014).

The common observation in such studies is that brand liking increases if the attributes associated with a specific phoneme are desirable for a particular product (Lowrey & Shrum, 2007; Yorkston & Menon, 2004). For example, brand names with front vowels are preferred to brand names with back consonants for the product *knife*. This preference reverses if the brand name refers to an SUV (Lowrey & Shrum, 2007). However, some sounds can also be

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onomatopoeia where the sound of a word imitates the sound an animal/object makes (e.g., “boom”, “bark”, “zip”). Yet, they apply to words and not single phonemes and are thus not counted as actual sound symbolism (Hinton et al., 1994; Sidhu & Pexman, 2018).

directly associated with positive/negative concepts, which influences brand name liking independent of the product category (Lowrey & Shrum, 2007).

To summarize, sound symbolism research shows that seemingly arbitrary features of brand names can influence brand liking. However, most sound symbolism research has focused on the role of single phonemes but has neglected the position of a phoneme within a name (for a notable exception, see Klink & Wu, 2014). However, an emerging research area shows that the specific *arrangement* of phonemes plays a crucial role in the liking of a brand name as well. This new research area investigates the impact of articulation dynamics and is often subsumed under the catchy name *articulatory in-out effect*, introduced and explained in the next section.

The Articulatory In-Out Effect and Articulation Dynamics

In this dissertation, I define the articulatory in-out effect as follows:

> The articulatory in-out effect describes the tendency to evaluate linguistic stimuli with an inward-oriented sequence of consonants more positively than those with an outward-oriented sequence of consonants (Ingendahl & Vogel, 2022b).

Articulating consonants[2] involves very specific places of articulation in our mouth (see Table 1 and Figure 2). For instance, in the word BODIKA we articulate the bilabial [b] with the lips at the front of the mouth, followed by the alveolar [d] with the tip of the tongue in the

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[2] As a caveat beforehand, please note that we often use the term consonant synonymously to consonant letter (e.g., “M”) in colloquial language. In phonetics, however, the term *consonant* refers to a specific *phoneme* (e.g., [m]). In this dissertation, I consistently use the term consonant for the phoneme and consonant letter for the letter.

middle of the mouth, and last, we form the uvular [k] with the lower end of the tongue in the rear of the mouth. Thus, the different places of articulation constitute a sequence from the outside to the inside – an inward sequence. For the word KODIBA, the same consonants are used but re-arranged in the opposite order – first a rear, then a middle, and last a frontal place of articulation, thus constituting an outward sequence. The articulatory in-out effect, as defined above, refers to the observation that linguistic stimuli with such an inward sequence are on average preferred to those with an outward sequence.

Note that this definition describes an effect on a very phenomenological and operational level without any underlying theoretical construct assumed. It refers to a mere difference in liking between letter strings with different consonant orders – without relying on concepts such as articulation dynamics, movements, trajectories, or even articulation at all, despite the effect's name in the literature and other definitions of the effect (e.g., Körner et al., 2019). This will become relevant throughout the course of this dissertation, and I will come back to this point later in the discussion.

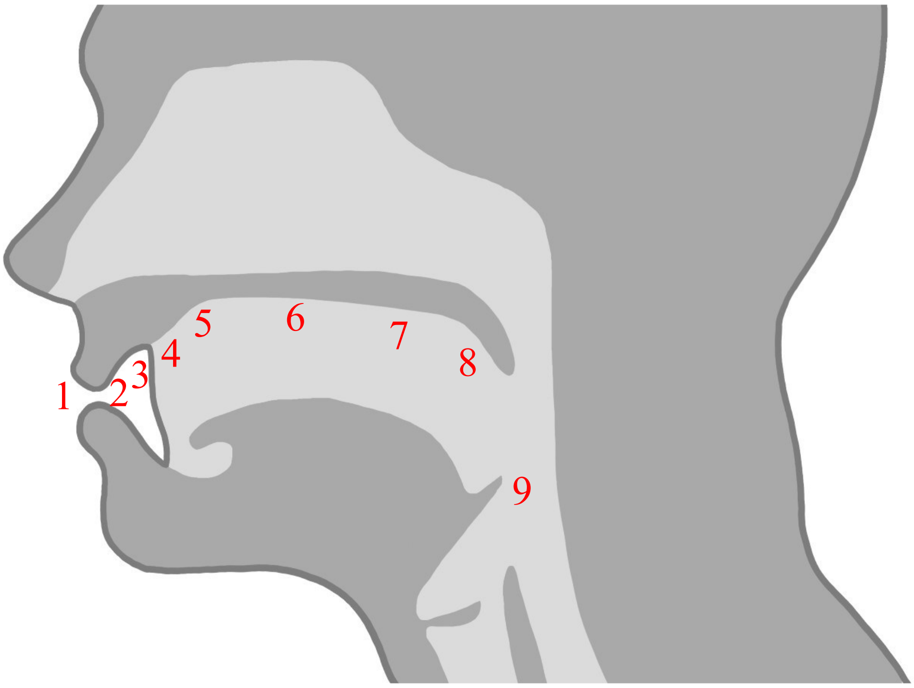
Also, note that this definition only includes evaluative judgments on linguistic stimuli. Research on other types of judgments and decisions, or judgments and decisions on objects or persons labeled with inward/outward names are referred to here as the broader research area of *articulation dynamics*, based on the most common term in the literature (Lindau & Topolinski, 2018b; Pathak et al., 2021; Topolinski et al., 2014).

Studying the In-Out Effect

Depending on the articulation system of a particular language, different consonant letters refer to different phonemes and thus different places of articulation. For instance, the consonant letter R is usually uttered as the guttural phoneme [r] in German, thus being a rear consonantal letter in German in-out effect research, whereas the same letter is usually pronounced as [ɹ] in English phonation (Pompino-Marschall, 2009). In German, the consonant letters B, M, P, F, and W are consistently articulated with phonemes formed at the front of the mouth, D, T, S, L, and N in the middle of the mouth, and G, K, and R in the rear of the mouth (Topolinski et al., 2014)[3]. Thus, other linguistic stimuli with an inward sequence in German would be PALIGU or METURI, whereas GALIPU and RUTEMI would be stimuli with an outward sequence.

Figure 2

Consonantal Articulation Places in English and/or German (Pompino-Marschall, 2009)



Note. The numbers refer to different consonantal articulation places which are further explained in Table 2.

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[3] This is at least the case for pseudowords with consonant-vowel syllables (e.g., BO-SA-GI). Of course, the consonantal letter S in a consonant cluster SCH refers to the phoneme ʃ (see Table 1).

Table 2

Specific Consonants in English and German and their Usage in In-Out Effect Research (Pompino-Marschall, 2009)

Consonant (IPA symbol)	Place of Articulation (Number in Figure 2)	Manner of Articulation	Consonant Letter in CVCVCV structure (English/ German phonation)	Example Word	Conceptualization in Previous In-Out Effect Research
p	Bilabial (1)	Plosive	P/P	**P**urple	Front
b	Bilabial (1)	Plosive	B/B	**B**all	Front
m	Bilabial (1)	Nasal	M/M	**M**other	Front
f	Labio-dental (2)	Fricative	F/F	**F**ace	Front
v	Labio-dental (2)	Fricative	V/W	**V**anity	Front
θ	Dental (3)	Fricative	--/--	**Th**anks	--
ð	Dental (3)	Fricative	--/--	**Th**is	--
t	Alveolar (4)	Plosive	T/T	**T**ea	Middle
d	Alveolar (4)	Plosive	D/D	**D**istant	Middle
n	Alveolar (4)	Nasal	N/N	**N**ose	Middle
s	Alveolar (4)	Fricative	S/S	**S**un	Middle
z	Alveolar (4)	Fricative	--/Z	**Z**oom	--
l	Alveolar (4)	Lateral Approximant	L/L	**L**ove	Middle
ʃ	Post-alveolar (5)	Fricative	--/--	**Sh**eep	--
ʒ	Post-alveolar (5)	Fricative	--/--	Plea**s**ure	--
ç	Palatal (6)	Fricative	--/--	**H**uge	--
j	Palatal (6)	Approximant	--/J	**Y**awn	--
k	Velar (7)	Plosive	K/K	**K**iss	Rear
ɡ	Velar (7)	Plosive	--/G	**G**iggle	Rear
ʀ	Uvular (8)	Vibrant	--/R	**R**übe (GER)	Rear
ʁ	Uvular (8)	Fricative	--/R	**R**ot (GER)	Rear
h	Glottal (9)	Fricative	H/H	**H**igh	--

Note. This summary does not include consonants that do not occur in English or German, such as retroflex or pharyngal consonants. Some of the consonants marked with -- have been used in single in-out papers (e.g., Topolinski & Boecker, 2016a), but for instance only in unpronounceable letter strings. IPA = International Phonetic Alphabet, ENG = English, GER = German.

The standard paradigm to study the in-out effect is a simple stimulus evaluation task (Bakhtiari et al., 2016; Ingendahl & Vogel, 2022b; Körner et al., 2019; Maschmann et al., 2020; Topolinski & Boecker, 2016a). Participants are presented with different inward/outward stimuli and tasked to evaluate each stimulus on a single-item measure (e.g., "How much do you like this word?" on a scale from 0 [not at all] to 10 [very much]). The stimuli themselves are usually pseudowords constructed from a sequence of consonant-vowel syllables (e.g., BO-DI-KA, KO-DI-BA). As long as the pseudowords end with a syllable where the consonant is more inward (outward) on the front-rear axis than the previous consonants, one can easily generate a pseudoword with an inward (outward) sequence. Most commonly, the pseudowords follow the structure front-middle-rear (inward; e.g., BODIKA) or rear-middle-front (outward; e.g., KODIBA). However, it is also possible to use merely two syllables (e.g., BOKA/KOBA) to find and study the effect (Körner & Rummer, 2021; Topolinski & Boecker, 2016a). Moreover, the effect can also be observed on mere letter pairs (e.g., BK/KB; Topolinski & Boecker, 2016a) or word fragments (e.g., B _ _ _ K _/ K _ _ _ B _; Maschmann et al., 2020).

Before I started this dissertation project, all in-out effect research had relied on fixed sets of ten (Topolinski et al., 2015) up to 282 stimuli (Topolinski et al., 2014) from which the experimenter draws a random subset for an individual participant. Despite the heterogeneity of stimuli in such lists, fixed stimulus sets can still be biased samples of the stimulus population and lead to skewed estimates of the in-out effect (Wells & Windschitl, 1999). Furthermore, as vowels have been shown to influence affective judgments, it is of utmost importance to control for the placement of vowels (Rummer et al., 2014; Topolinski & Boecker, 2016a; Yu et al., 2021b, 2021a).

To avoid such issues and improve the standard paradigm, I used a slightly different approach to study the in-out effect – random ad-hoc generation of stimulus materials for each individual participant. For that purpose, the consonantal letters from each place of articulation were shuffled (i.e., front consonants: B/M/P → P/B/M), and random vowels were entered after each consonant. This procedure leads to a very diverse set of stimuli. For instance, using merely three consonants per place of articulation would allow for 1620 different inward words (e.g., BODIKA, METUPI, …). Of course, such a procedure also comes with certain challenges. For instance, not all consonant letters are invariant to their position within a word, implying that not all consonantal letters can be used to construct the stimuli. In English, for instance, the g in the word *guitar* is pronounced with the velar [g], but in *damage* with the post-alveolar [ʒ]. Also, this procedure inevitably leads to some few words similar or even identical to existing words (e.g., GITARE in German). To control for this, we repeated each analysis within each paper without such trials, which always led to nearly identical findings.

Robust and Replicable?

Due to substantial differences in phonetic systems between languages, many linguistic phenomena are difficult to generalize. For instance, whereas the Bouba-Kiki effect emerges in different languages and scripts (Ćwiek et al., 2022), the [gl] cluster for the concept "light" is exclusive to the English language (Sidhu & Pexman, 2018).

In contrast, the in-out effect has proven to be highly robust (Ingendahl, Vogel, & Topolinski, 2022). The articulatory in-out effect has so far been found in languages as diverse as German (Ingendahl & Vogel, 2022b; Topolinski et al., 2014), English (Topolinski et al., 2014), French (Rossi et al., 2017), Portuguese (Garrido et al., 2019; Godinho & Garrido, 2016, 2021), Turkish, and Ukrainian (Godinho, Garrido, & Horchak, 2019). Thus, whereas most studies have been conducted within the Indo-European language family in Latin script, there is also evidence that the effect is present in other language families (i.e., Turkic) and scripts (i.e., Cyrillic; Godinho, Garrido, & Horchak, 2019).

The effect does not require *overt* articulation of the stimuli, as it can also be found under silent reading or in studies with a mere auditory presentation (Topolinski & Boecker, 2016a). Furthermore, it does not even require *covert* articulation and subvocalization: Co-occurrent whispering and other oral motor tasks such as chewing gum do not harm the effect (Lindau & Topolinski, 2018a). The presentation times of the stimuli can go as low as 50ms but not lower – which is the typical threshold for phonological activation in language processing (Ferrand & Grainger, 1993; Gerten & Topolinski, 2018). Overall, these findings suggest that the effect does not depend on mere orthographic processing but requires a bare minimum of phonological activation; yet, it is not interfered by concurrent speech production processes.

Beyond mere stimulus evaluation and the specific phenomenon of the articulatory in-out effect, the research area of articulation dynamics has revealed important implications of the in-out effect on more distal outcomes, especially in social and consumer contexts. For instance, eBay sellers with an inward name are seen as more trustworthy than eBay sellers with an outward name (Silva & Topolinski, 2018). Dishes labeled with inward names are judged as more palatable (Topolinski & Boecker, 2016b), also leading to more consumption of these dishes (Rossi et al., 2017). Fictional brands or products are evaluated more positively when they carry an inward name (Godinho & Garrido, 2017). Also, consumer products labeled with inward names exert a higher willingness to pay (Topolinski et al., 2015). Beyond social judgments, the in-out effect also affects further information processing, such as recognition memory (Lindau & Topolinski, 2018b): Individuals show a familiarity bias towards inward words (i.e., they think an inward word has been encountered before).

Overall, previous literature on articulation dynamics and the articulatory in-out effect suggests a robust impact across judgment domains. In fact, I am only aware of very few studies that point at possible attenuations (or even reversals) of the effect, which will be discussed in the upcoming sections on the underlying theoretical processes. This robustness should not easily be taken for granted in a research discipline (social/cognitive psychology) with generally low replication rates (e.g., Nosek et al., 2022; Open Science Collaboration, 2015). Yet, by the same token, robustness[4] across different contexts might also come with the disadvantage that it becomes difficult to identify the underlying processes (cf., Fabrigar et al., 2020).

To conclude, the in-out effect is a robust phenomenon that generalizes across languages, materials, and settings. Despite its rather recent discovery in 2014, it has sparked a lot of interest among the scientific community, with a total sum of 23 papers (until I started this dissertation project in late 2019) published in the most prestigious outlets in social and cognitive psychology.

Thus, the question arises of how to explain this phenomenon. Up to the point when I began studying the in-out effect in late 2019, three theoretical accounts had been proposed to explain the phenomenon: the oral approach/avoidance account by Topolinski and colleagues (2014), the consonant preference account by Maschmann and colleagues (2020), and the fluency account by Bakhtiari and colleagues (2016). In the following, I will explain these three accounts and the broader theoretical fundaments underneath them. For each account, I will briefly summarize empirical findings that are either consistent or inconsistent with this account. I will go into slightly more detail on the empirical work I conducted myself together with colleagues to test these accounts.

[4] Within this dissertation, I use the terms robustness to refer to the context insensitivity or generalizability of the in-out effect, and not as insensitivity to the statistical or data analytical method (Nosek et al., 2022).

Theoretical Processes

Oral Approach/Avoidance

Ingendahl, M., & Vogel, T. (2022). Choosing a brand name that's "in" – disgust sensitivity, preference for intuition, and the articulatory in-out effect. *Personality and Individual Differences*, *185*, 111276. https://doi.org/10.1016/j.paid.2021.111276

Ingendahl, M., Maschmann, I. T., Embs, N. M., Maulbetsch, A., Vogel, T., & Wänke, M. (2022). *Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.* Manuscript in preparation.

The starting point of in-out effect research was the idea of oral approach and avoidance states induced by inward and outward articulation (Topolinski et al., 2014); an idea based on the broader framework of embodied cognition (Barsalou, 2007; Dove, 2011; Krishna & Schwarz, 2014; Schwarz & Lee, 2018). Despite different meanings in different research areas and scientific disciplines, the core concept behind embodied cognition is that cognitive processes do not operate (exclusively) in abstract amodal form but involve sensory information as well.

In the domain of evaluative judgments, embodied cognition often refers to studying how bodily sensations are used as information for evaluative judgments (Schwarz & Lee, 2018). Bodily states can serve as situationally accessible information if they are considered diagnostic for evaluating an object (Schwarz, 2011). One piece of information is whether we approach or avoid a specific object: Approaching a stimulus elevates evaluation, and avoiding it decreases evaluation (Neumann et al., 2003; Van Dessel et al., 2018). Such approach/avoidance behaviors can also be rather subtle, for instance, in the form of proprioceptive feedback: In a seminal study, Cacioppo and colleagues (1993) let participants evaluate Chinese ideographs. During this evaluation task, participants had to flex or extend their arms by pressing them against the underside or upside of a table. When flexing an arm (and thus performing an approach behavior), the Chinese ideographs were rated more positively than when extending an arm (and thus performing an avoidance behavior).

Furthermore, actively executing such motor actions may not even be necessary to influence evaluative judgments (e.g., Van Dessel et al., 2014). One core assumption of the embodied cognition framework is that the mere mental activation of an object activates a sensory representation of the said object (Barsalou, 2007; Dove, 2011; Schwarz & Lee, 2018). In other words, the act of physically interacting with the object is *simulated*. For instance, Elder and Krishna (2012) showed participants advertisements for different food products (e.g., a cup of soup). The authors manipulated whether the spoon was oriented towards the dominant or the non-dominant hand in these advertisements. If the consumption of the food product is simulated, this simulation should be less effortful when the spoon was oriented towards the dominant hand. Thus, one should expect a more positive evaluation of the food than when the spoon was oriented towards the non-dominant hand. This turned out to be the case[5], speaking for the role of mere simulations of motor actions. Furthermore, the effect vanished when a concurrent task interfered with motor simulations (e.g., when simultaneously pressing a clamp). The role of motor simulations has also been studied in language. In fact, a large body of research suggests that language comprehension is also based on embodied processes (cf., Gianelli & Kühne, 2021). For instance, the mere presentation of effector-

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[5] Note that this finding could not be replicated in later studies (Pecher & van Dantzig, 2016), but recent studies show conceptually similar findings to Elder and Krishna (Chen & Lin, 2021). In general, many prominent findings from embodied cognition have been found at least difficult to replicate (Morey et al., 2021; Wagenmakers et al., 2016; Westerman et al., 2015). At the current state, it is often unclear whether these mixed findings are due to false positives or yet unidentified moderators (Hauser & Schwarz, 2020; Noah et al., 2018).

specific words (e.g., “walking”) is sufficient to activate motor-cortical areas that would be involved in such action (Pulvermüller, 2005; Pulvermüller et al., 2001).

Based on this broader framework of embodied cognition and especially the research on approach/avoidance behavior and evaluative judgments, Topolinski et al. (2014) proposed an embodied explanation on the in-out effect such that inward/outward articulation induces motivational states of approach and avoidance. Their argumentation can be divided into two central hypotheses, which are in the following referred to as the *deglutition hypothesis* and the *simulation hypothesis*. These two hypotheses are not in contrast; instead, the deglutition hypothesis explains the origin of the in-out effect, whereas the simulation hypothesis explains the process by which this origin influences the liking of an individual stimulus.

The deglutition hypothesis rests on the idea that both phylogenetically and ontogenetically, the mouth’s primary function is deglutition – food ingestion (e.g., swallowing, sucking) and expectoration (e.g., spitting, vomiting). The articulation of language, however, relies on very similar motorial patterns as deglutition (Rozin, 1999; Topolinski et al., 2014). Specifically, the motor patterns of inward articulation are similar to those of food ingestion, whereas motor patterns of outward articulation are similar to those of food expectoration. Food ingestion generally comes with positive consequences (e.g., nourishment) and food expectoration with negative consequences (e.g., being poisoned). Therefore, inward motor patterns are expected to trigger motivational states of approach and positive affect, whereas outward motor patterns are expected to trigger motivational states of avoidance and negative affect.

The second hypothesis – the simulation hypothesis – is that reading (or listening to) an inward/outward word triggers a motorial simulation of articulating the word, activating the positive approach/negative avoidance states associated with these motor patterns. Thus, mere silent reading of KODIBA elicits a motorial simulation of articulating the word, activating the positive affect associated with the motorial pattern.

In the following, I will briefly discuss empirical evidence in favor or against each of these two hypotheses.

The Deglutition Hypothesis: Inward/Outward Dynamics and Food Consumption

One central prediction that can be derived directly from this framework is universality. Inward/outward dynamics should resemble motor patterns of food deglutition, and food consumption/expectoration should be positive/negative irrespective of culture, language, or the specific stimulus material. The effect's robustness across languages therefore supports the oral approach/avoidance account. Apart from this, however, the deglutition hypothesis remains rather vague and does not allow specific predictions. For instance, it remains unclear whether the association between articulation dynamics and food consumption is innate or shaped by learning. Also, it remains open how automatic or hard-wired this association is, and thus when the in-out effect should be modulated by context.

Some authors have proposed that if eating-related associations are responsible for the phenomenon, then bodily sensations of inward/outward movements might be more diagnostic for evaluative judgments on edible (vs. inedible) objects, thus strengthening the in-out effect (Topolinski et al., 2017). This indeed seems to be the case in some studies (Topolinski et al., 2017), even when thoroughly controlling for the valence of edible/inedible objects (Godinho, Garrido, Zürn, et al., 2019). Furthermore, some studies even indicate that for products with an outward-oriented consumption direction (e.g., bubble gums that are primarily used to blow gum bubbles), outward names fit better than inward names (Topolinski et al., 2017). Yet, the effects are empirically inconsistent across these studies. Also, a recent study assessed specific taste expectations for products with inward and outward names (Pathak et al., 2021). Participants tended to associate outward words more with a sweet taste and inward words more with a bitter taste – contrary to what one could expect based on the deglutition hypothesis.

Other researchers proposed that not only pure inward or outward patterns but also compounds of inward and outward patterns could be associated with affect. Topolinski and Bakhtiari (2016) reasoned that inward-outward sequences (e.g., FOLOKOLOF) resemble the act of first ingesting food (FOLOK) and then spitting it out immediately (KOLOF), thus being more negative than outward-inward sequences (e.g., KOLOFOLOK) for which no similar resemblance exists. Over multiple studies, Topolinski and Bakhtiari (2016) indeed demonstrated that such inward-outward compounds are evaluated more negatively than outward-inward compounds.

Recent research argued that food-related states of an individual could modulate the size of the in-out effect as well (Maschmann et al., 2020). Specifically, hunger induction could make inward movements even more appealing and thus increase the in-out effect. In contrast, disgust induction could make inward movements less appealing and thus reduce the in-out effect (Maschmann et al., 2020). However, neither hunger nor disgust induction moderates the in-out effect (Maschmann et al., 2020; Topolinski & Boecker, 2016b).

Due to these mixed findings, I set out to further test this deglutition hypothesis in the oral approach/avoidance account together with Tobias Vogel (Ingendahl & Vogel, 2022a). We chose a new methodological approach that had not been utilized in in-out effect research before – testing process explanations via interindividual differences in the in-out effect. Based on the oral approach/avoidance account, we expected interindividual differences in the in-out effect to correlate with two personality traits – disgust sensitivity and preference for intuition.

Disgust sensitivity is the "general tendency to respond with the emotion of disgust to any given situation" (van Overveld et al., 2006, p. 1412). The emotion disgust is considered to be an adaptive oral defense mechanism that helps humans avoid diseases and infection (Haidt et al., 1994). In line with this perspective, individuals high in disgust sensitivity experience more negative affect when expectorating food (Olatunji et al., 2008) and thus also show elevated levels of fear of vomiting (van Overveld et al., 2008). If indeed inward dynamics resemble movements of food ingestion, people high in disgust sensitivity should experience more negative affect when expectorating food, thus leading to a stronger in-out effect. However, individuals high in disgust sensitivity even experience disgust at food intake (Ammann et al., 2018), which might reduce the in-out effect for such individuals. Thus a moderation in both directions is possible based on the oral approach/avoidance account.

The preference for intuition is a personality trait that originates from the cognitive-experiential self-theory, one of the classical dual-process models in social psychology (Epstein et al., 1996). This model distinguishes between a rational and an experiential system of information processing. The rational system is slow, deliberative, and rule-based, whereas the experiential system is fast, affect-based, and automatic. Notably, the model also assumes that people differ in their habitual preference for engaging in rational or experiential processing (Betsch, 2004; Epstein et al., 1996). Individuals with a high preference for intuition are generally more likely to rely on affect and gut feelings in judgments (Betsch, 2008; Richetin et al., 2007), including evaluative judgments (van Giesen et al., 2015). Accordingly, they should also rely more on affect and gut feelings when evaluating inward/outward words, leading to a stronger in-out effect for individuals high in preference for intuition.[6]

We thus set out to test these hypotheses. In a single study (N = 298), we let participants evaluate inward/outward brand names and also assessed the two personality traits. The results are visualized in Figure 3. Despite a robust difference in the evaluation of inward/outward brand names, neither disgust sensitivity nor preference for intuition

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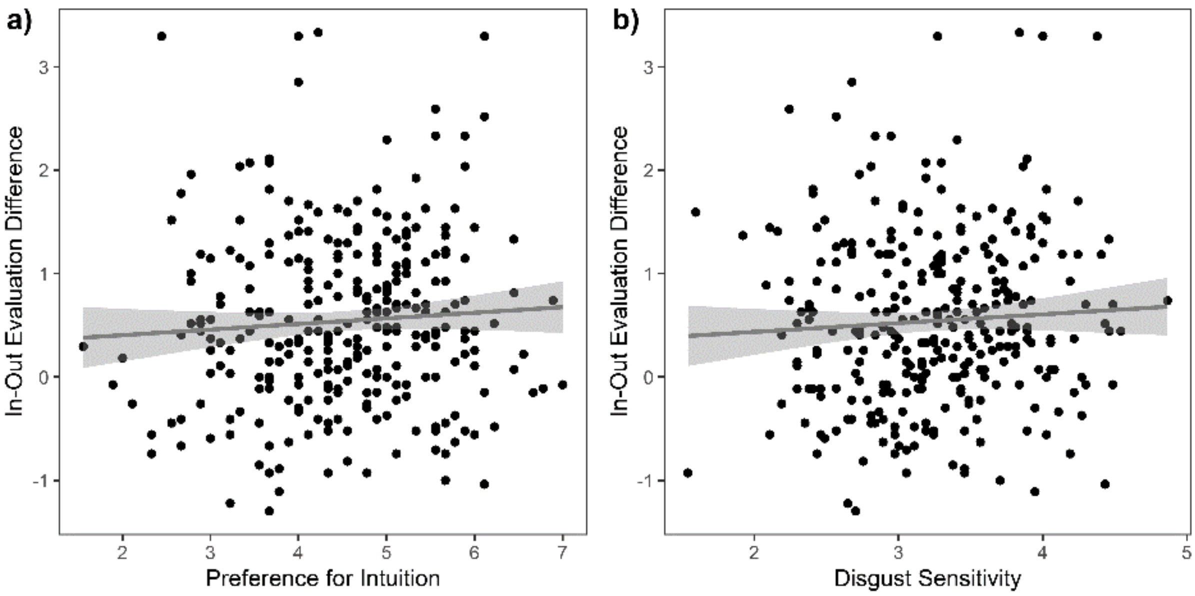
[6] Note that this hypothesis would also be predicted by the fluency account later described in this dissertation.

moderated this effect. Thus, we do not find any support for the oral approach/avoidance account within this individual difference framework.

Figure 3

Evaluation of Inward vs. Outward Brand Names by Personality (N = 298) in Ingendahl and Vogel (2022a)



Note. Shaded areas represent 95% confidence intervals.

Note that these null findings cannot directly falsify the oral approach/avoidance account as there are multiple reasons why we do not find any moderations: As discussed before, theorizing on disgust sensitivity allows moderations in different directions, which might simply cancel each other out. In defense of the deglutition hypothesis, one might argue the association between the motor patterns of food ingestion and positive/negative affect might be simply too universal to be moderated by individual differences in disgust sensitivity. Also, there are findings from disgust sensitivity research that show no direct association between disgust sensitivity and behavioral disgust reactions (Stark et al., 2005), suggesting that disgust sensitivity might not capture a physiological basis that is postulated in the deglutition hypothesis.

Yet, our findings fit into the bigger picture with overall mixed evidence on the deglutition hypothesis (Maschmann et al., 2020; Pathak et al., 2021; Topolinski et al., 2017). Further research might be necessary here, but as long as this deglutition hypothesis remains as unspecified as now, it is difficult to test it critically. But what about the second hypothesis, the simulation hypothesis?

The Simulation Hypothesis: The Mental Representation Underlying Inward/Outward Stimuli

In the original publication on the in-out effect, Topolinski and colleagues (2014) report a study on a small sample of aphasic patients who had suffered brain damage in areas necessary to simulate articulation of words. No significant in-out effect was found in this study, supporting the claim that motor simulations are necessary for the effect. Yet, the sample size was small, and it is uncertain whether the aphasia patients suffered from other comorbidities that affected their judgments.

In a later series of experiments, Lindau and Topolinski (2018a) tried to suppress motorial simulation by manipulations that had proven successful in suppressing oral motor effects in previous research (Topolinski & Strack, 2009). For instance, participants had to whisper words or chew chewing gum during the evaluation task. None of these manipulations affected the in-out effect[7]. Lindau and Topolinski concluded that either the in-out effect does not depend on covert articulation simulations, or the articulation simulations in the in-out effect are not interfered with by concurrent oral/verbal tasks.

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[7] As discussed later, we also replicated this non-finding in a student project.

Due to these mixed findings, I set out to test this hypothesis of articulation simulations in research conducted with students and colleagues (Ingendahl, Maschmann, et al., 2022). Yet, I targeted a slightly different aspect of the simulation hypothesis that had not been addressed before – the mental representation underlying inward/outward dynamics. The simulation hypothesis implies that individuals should have a generalized representation of an inward/outward dynamic independent of the specific consonants used. As an illustration for such a generalized representation, consider the two inward words BODIKA and MENURO. Both words contain entirely different phonemes, yet, they both have an inward dynamic consisting of a front, middle, and rear place of articulation. The oral approach/avoidance account would predict that it is not the specific consonant sequence that is associated with positive/negative affect but the mental representation of the inward/outward dynamic elicited by the consonant sequence. Specifically, the oral approach/avoidance account would predict that when encountering an inward/outward word (e.g., “BODIKA”), the places of articulation would need to be extracted and put into a sequence (“front-middle-rear”), which constitutes the simulated articulation dynamic (“inward”). This dynamic (“inward”) is associated with affective states, leading to the in-out effect. The question is, how can we test whether there is such a generalized representation?

We decided to do so via evaluative conditioning (EC; De Houwer et al., 2001; Hofmann et al., 2010). EC refers to the change in the liking of a stimulus due to its co-occurrence with a valenced stimulus. For instance, let us say that the word “BODIKA” is paired with a stimulus of negative valence (e.g., molded food). In this context, the stimulus pairings would decrease the liking of “BODIKA”, but increase the liking of “KODIBA” – leading to an attenuation or even a reversal of the in-out effect for these two words.

Crucially, EC does not only impact the single conditioned stimuli (CS), but the effects generalize beyond individual stimuli (Glaser & Kuchenbrandt, 2017; Halbeisen et al., 2020; Högden et al., 2020; Hütter et al., 2014; Hütter & Tigges, 2019; Jurchiș et al., 2020; Kocsor &

Bereczkei, 2017; Luck et al., 2021; Vogel et al., 2021). Specifically, EC effects generalize to stimuli similar to the original CS (Gawronski & Quinn, 2013; Halbeisen et al., 2020; Högden et al., 2020; Vogel et al., 2021). Furthermore, this similarity can also be on a rather abstract level, and EC generalization even occurs when participants are not fully aware of the similarity (Högden et al., 2020; Jurchiș et al., 2020; Kocsor & Bereczkei, 2017; Vogel et al., 2021). In one notable study, Jurchiș and colleagues (2020) presented participants with letter strings from two complex artificial grammars. Whereas strings from one grammar were conditioned positively, strings from the other grammar were conditioned negatively. Jurchiș and colleagues (2020) found that the EC effect generalized to new strings from these abstract grammars even if participants were unaware of the grammar structure.

In our example, a similar abstract structure of inward/outward words is the articulation dynamic. Thus, if there is a generalized representation behind inward/outward words that is independent of the specific consonants, the EC effect should generalize even to words that share only the articulation dynamic with the conditioned words. So, for instance, conditioning BODIKA and KODIBA should influence the liking of MENURO and RENUMO.

To test this idea, I conducted three experiments with colleagues and students (Ingendahl, Maschmann, et al., 2022). All three experiments followed a similar approach and only differed slightly in the materials. Participants were presented with inward and outward words and positive and negative pictures in a standard evaluative conditioning procedure. In an experimental group, inward words were conditioned negatively and outward words positively, thus conditioning *against* the in-out effect. In a control condition, we conditioned in the direction of the in-out effect, meaning that inward words were paired with positive stimuli and outward words with negative stimuli. After the conditioning procedure, participants evaluated inward and outward words in order to assess the in-out effect. Crucially, the words in the conditioning phase were generated only from a subset of all possible consonants. In the rating phase, three different types of inward/outward words were rated:

a) Words that were presented in the conditioning phase
b) Words constructed from the same consonant sequences as in the conditioning phase
c) Words constructed from entirely new consonants that had not been used in the conditioning phase

With these three word types, it was possible to disentangle conditioning effects on

a) Specific inward/outward words (e.g., BODIKA → BODIKA)
b) Specific consonant sequences in inward/outward words[8] (e.g., BODIKA → BADIKO)
c) The generalized representation of inward/outward dynamics (e.g., BODIKA → MENURO)

The results of these experiments are visualized in Figure 4. In all three experiments (and an integrative data analysis), the EC procedure reversed the in-out effect such that inward words were rated less favorable than outward words when inward words were conditioned negatively. However, this moderation occurred exclusively for the conditioned words and the words constructed from the same consonant sequences – but not for the new-consonant words. For these word types, no moderation occurred in either of the experiments. Instead, we found a standard in-out effect[9].

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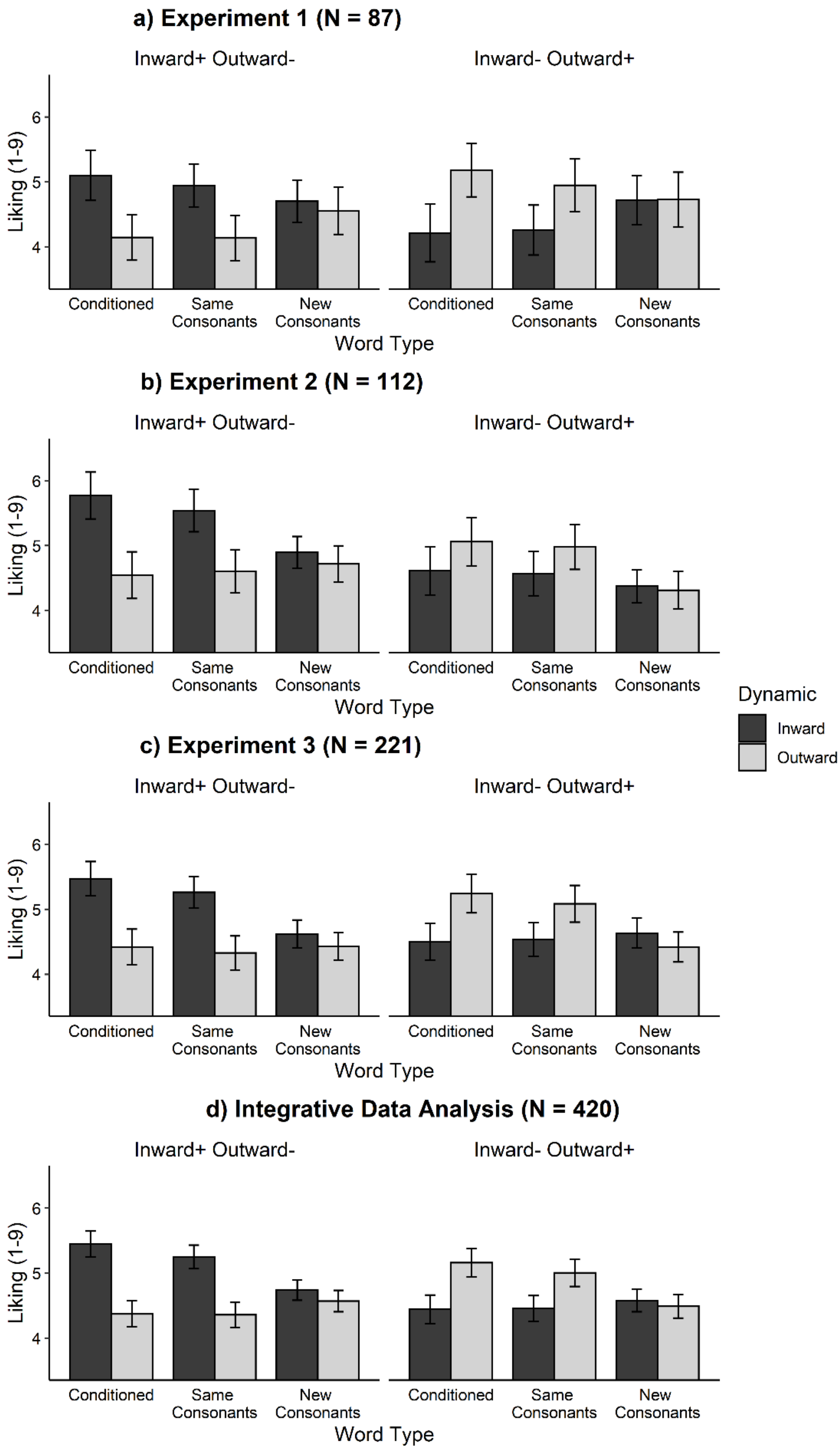
[8] These words are not of major theoretical relevance, but can serve as a manipulation check whether EC effects generalize at all in the paradigm.

[9] Except in Experiment 1, where no in-out effect was found for the new-consonant words. I expect that this is most likely an issue of statistical power, as the number of rated new-consonant words (and also the number of participants) was lowest in this Experiment.

Figure 4

Mean Word Evaluation in all Experiments of Ingendahl et al. (under review)



Note. Error bars represent 95% confidence intervals.

These findings can be interpreted in two ways: First, they imply that there is no generalized mental representation underlying inward/outward stimuli. Despite strong EC effects not only for conditioned inward/outward words, but also for words that contained the same consonant sequences as inward/outward words, new-consonant words were unaffected by the EC procedure. This interpretation would speak against the oral approach/avoidance account and its simulation hypothesis that requires such a generalized mental representation. As a second possibility, and in defense of the oral approach/avoidance account, the EC procedure might have simply not impacted the association of inward/outward dynamics with positive/negative affect. For instance, the association of inward/outward dynamics with positive/negative affect might simply be too strong to be influenced by a 15-minute conditioning procedure. Also, EC generalization is more effective if participants are aware of the similarity between the CS and the new stimuli (Glaser & Kuchenbrandt, 2017; Jurchiș et al., 2020). As participants are almost never aware of the articulation dynamics in the word materials, weaker EC generalization might have occurred in our paradigm.

Despite this ambiguity in the interpretation of the results, the experiments reveal an important boundary condition of the in-out effect relevant in everyday life. The effect for a specific word can quickly become overshadowed by individual associations with positive/negative concepts. Thus, the outward name “ROLF” may be positive if it is associated with a friendly person with a Swiss accent. Furthermore, the results cast doubts on an idea expressed by Topolinski and Bakhtiari (2016) that inward/outward words might occur more frequently in positive/negative words in natural language, leading to a learned association of inward/outward dynamics with positive/negative valence. Whereas our findings are mute about whether such an association exists in natural language, they nevertheless show that such an association does not simply generalize to inward/outward dynamics and is therefore unlikely the cause of the in-out effect.

Interim Conclusion

Overall, both the deglutition hypothesis and the simulation hypothesis have received rather mixed evidence. The data from my own studies further consolidate this impression. Yet, one can not easily say that these findings falsify the oral approach/avoidance account. Neither the modulation by the personality traits nor the modulation by EC is eventually a conditio sine qua non. However, what is such a conditio? How could we falsify this account? Due to its conceptual vagueness, I doubt that there is any way to falsify it eventually. The major challenge is that the account does not specify how automatic or “hard-wired” these processes work and thus how much the effect should be sensitive to context. Thus, all manipulations targeted to reduce or enhance the effect can support the account in case of a moderation. Still, they can never eventually falsify it if there is no moderation.

I am not the first to raise such criticism on the oral approach/avoidance account (Maschmann et al., 2020). Due to these mixed findings on and lack of specificity of the oral approach/avoidance account, other researchers searched for new alternative theories on the in-out effect. One of the most intriguing theories was offered recently by Maschmann et al. (2020) and will be discussed in the next section: consonant preferences.

Consonant Preferences

Ingendahl, M., & Vogel, T. (2022). The articulatory in-out effect: Driven by consonant preferences? *Journal of Personality and Social Psychology*, *122*(2), e1–e10. https://doi.org/10.1037/pspa0000276

Recently, Maschmann and colleagues (2020) proposed a new and provocative account on the in-out effect. This account is provocative such that it questions the core assumption of all previous in-out effect research – that it is caused by preferences for inward over outward *articulation dynamics*. Instead, Maschmann et al. (2020) argue that the effect can be traced to the two following causes:

a) People have a preference for some consonants over others. For instance, they prefer front consonants (e.g., [b], [p]) over rear consonants (e.g., [k], [r]).
b) This preference is enhanced if the consonants appear at the beginning of a stimulus than at later positions. [10]

Hence, the preference for an inward stimulus (e.g., BODIKA) over an outward stimulus (e.g., KODIBA) is due to the isolable preference for the front consonant [b] over the rear consonant

[10] Note that there is a conceptual difference between enhanced preferences for the consonants and a stronger impact of a consonant preference on stimulus liking. Empirically, however, these two assumptions have not been disentangled yet as this would require asking for the evaluation of a single consonant at a specific position within a linguistic stimulus. However, the two assumptions lead to the same conclusion for the evaluation of the whole stimulus, namely that the empirical effect of later consonants on stimulus liking is weaker than the effect of earlier consonants within a stimulus.

[k], which is stronger at the beginning than the end of the word. Several aspects of this theory are noteworthy:

First, one could criticize this consonant preference account because it does not *explain* the in-out effect, but simply replaces the effect with a different effect. Consonant preferences and position-specific effects on stimulus evaluation replace preferences for articulation dynamics[11]. However, where do these consonant preferences come from? Maschmann et al. (2020) discuss that the preference for front consonants might come from early language acquisition, which usually starts with front consonants, signaling that front consonants are easier to articulate (MacNeilage & Davis, 2000). However, this is only discussed post hoc, and not empirically tested. Also, why is the consonant preference stronger at stimulus onset positions? Maschmann et al. draw parallels to the within-word primacy effect in lexical access, which shows that the first letter is the most important factor for word identification – but again, this only discussed post hoc, and not empirically tested. Last, the account remains silent about how people integrate the liking of single consonants into the judgment of an overall stimulus.

Second, from the perspective of previous in-out effect research, this consonant preference account reduces the in-out effect to an epiphenomenon due to processes unrelated to articulation dynamics. By doing so, however, it also allows for predictions beyond inward/outward words: A stimulus with the letter sequence B-M (two front consonants)

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[11] In Ingendahl and Vogel (2022b), we use the term articulation *trajectory* because Maschmann et al. (2020) used it when introducing the consonant preference account. However, there is no conceptual difference between articulation dynamics and articulation trajectories. To be consistent with the rest of the dissertation, I decided to use the more common term, articulation dynamics, here.

should even be preferred to B-K, with one front and one rear consonant, but an inward dynamic. Also, stimuli with a sequence such as K-B (with one rear and one front consonant and also an outward dynamic) should be preferred to K-R (two rear consonants). In line with this prediction, Maschmann et al. (2020) show in their critical experiments 9 and 10 that this is indeed the case for word fragments (e.g., B _ _ _ M _ > B _ _ _ K _ > K _ _ _ B _ > K _ _ _ G _).

Despite strong empirical evidence in support of consonant preferences provided by Maschmann et al. (2020), I was skeptical about whether they actually explain the in-out effect, due to both empirical and theoretical arguments:

First, previous in-out effect research by Topolinski and Bakhtiari (2016) had shown that individuals prefer stimuli with first an outward and then an inward component (e.g., KOLOFOLOK) over those with first an inward and then an outward component (e.g., FOLOKOLOF). The consonant preference account would predict the opposite pattern because these inward-outward stimuli both start and end with a front consonant, whereas outward-inward stimuli both start and end with a rear consonant.

Second, word fragments might be a paradigm suited to study consonant preferences. However, it is questionable whether they are a valid paradigm to falsify the original conceptualization of the in-out effect as a preference for inward over outward dynamics, as postulated in the oral approach/avoidance account. Specifically, it remains unknown whether fragments like _B _ _ _ _K_ actually follow an inward/outward articulation dynamic due to the removal of everything except the first and the last consonant. If you were tasked to read this stimulus aloud, you might pronounce it as [b] – break – [k], which is not a dynamic but merely two isolated consonants. Also, even if these fragments contain an articulation dynamic, it is uncertain whether they are mentally represented in an embodied way. Several dualistic models on embodied cognition propose that linguistic stimuli can be processed in both an amodal and a modal system (e.g., Barsalou et al., 2008). These models also predict that once amodal processing is sufficient to solve a task, a mental simulation in the modal system is not required (Barsalou et al., 2008; Solomon & Barsalou, 2004). Evaluating the word fragments does not require a modal simulation system because one can merely evaluate the two consonants in isolation. Therefore, it is uncertain whether word fragments are influenced by the liking of an inward/outward dynamic (in case they actually contain one).

Both arguments suggested that a more critical test of the consonant preference account was necessary, with materials for which articulation dynamics are more likely to influence stimulus liking than in the studies of Maschmann et al. (2020). To provide such a test, Tobias Vogel and I (2022b) conceptually replicated Experiment 9 of Maschmann et al. (2020) with the following crucial difference: To make sure that articulation dynamics can eventually influence stimulus liking, we went back to the original in-out effect paradigm that relies on pseudowords (Topolinski et al., 2014). Thus, participants evaluated pseudowords where we orthogonally varied the starting and the ending consonant, leading to front-front words (e.g., BODIMA), front-rear (inward) words (e.g., BODIKA), rear-front (outward) words (e.g., KODIBA), and rear-rear words (e.g., KODIGA). In this paradigm, we expected the following:

If consonant preferences drive the in-out effect, people should prefer words with more front consonants over those with fewer front consonants. Also, the effect of a front (vs. rear) consonant should be more pronounced at the beginning of a stimulus, leading to a pattern as found by Maschmann et al. (2020).

H1: front-front > front-rear (inward) > rear-front (outward) > rear-rear.

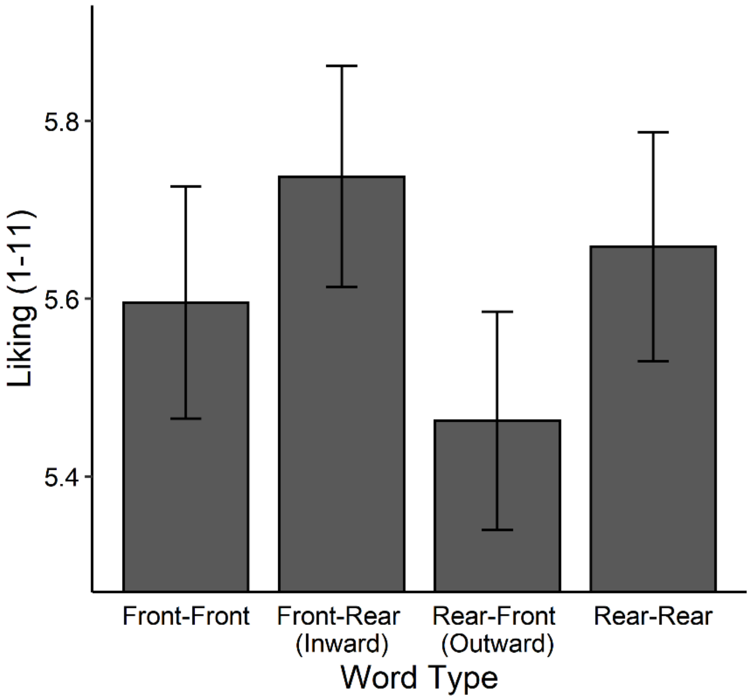
If, however, articulation dynamics drive pseudoword liking as originally proposed by Topolinski et al. (2014), one would expect that stimuli with an inward dynamic (front-rear) are preferred over those with an outward dynamic (rear-front). Front-front (e.g., BODIMA) and rear-rear (e.g., KODIGA) words consist of both short inward and outward components (e.g., BOD-DIMA or KOD-DIGA) and should thus receive average ratings between front-rear and rear-rear words. Thus, we would expect:

H2: front-rear (inward) > (rear-rear, front-front) > rear-front (outward)

In a single preregistered study with *N* = 349, we tested these hypotheses within the standard pseudoword evaluation task (overall 96 words per participant). The mean word evaluation is depicted in Figure 5. In this study, we observed that word evaluation perfectly followed the pattern of H2, but not H1. Thus, front-rear (inward) words received the most favorable evaluations, followed by rear-rear and front-front words on an equal level, while rear-front (outward) words received the least favorable evaluations (see Figure 5).

Figure 5

Mean Word Liking by Word Type (N = 344) in Ingendahl and Vogel (2022b).



Note. Error bars depict 95% credibility intervals from a Bayesian ANOVA.

These results clearly speak against the consonant preference account by Maschmann et al. (2020) but support the original idea behind the in-out effect based on preferences for inward over outward articulation dynamics.

Yet, how can these results be integrated with the findings of Maschmann et al. (2020)? After all, they provide strong evidence in high-powered and preregistered experiments for consonant preferences and their influence on the evaluation of word fragments. We find completely opposite results by changing only a minor detail in the design. Thus, the failure to conceptually replicate their findings does not mean that their results are wrong – in fact, other groups and we replicated them in other studies (Körner & Rummer, 2021). Instead, the deviant results clearly signal that the in-out effect is a multiprocess phenomenon. I will discuss this idea in the next section.

An Integrative Model?

The following section is based on unpublished data that has not (yet) been written up as a manuscript. However, the preregistrations for these studies are provided below in case methodological questions arise.

The results from Maschmann et al. (2020) suggest that consonant preferences drive stimulus liking for word fragments. Our findings suggest that articulation dynamic preferences drive stimulus liking for pronounceable pseudowords. Thus, it seems that in some instances, people seem to prefer inward over outward stimuli solely based on the identity of their consonants; in other cases, people seem to prefer them because of their articulation dynamic. What decides whether consonant preferences or dynamic preferences drive stimulus liking?

In the discussion of Ingendahl and Vogel (2022b), we develop an integrative model for these different processes. Based on the dual-system theories from embodied cognition research discussed above (Barsalou et al., 2008), one could assume that the evaluation of linguistic stimuli can take place in two different systems: a *modal simulation system* where the movement of articulating a linguistic stimulus is executed and an *amodal linguistic system* where linguistic associations of a stimulus are retrieved, such as the liking of the single consonants. In this model, we predict that when a stimulus is represented in the modal simulation system, the articulation dynamic will influence stimulus liking. If it is represented in the amodal linguistic system, consonant preferences will influence stimulus liking. We expected two main determinants for which system is used:

a) Does the stimulus evoke an actual (inward vs. outward) articulation dynamic?
b) Does the modal system have the capacity to simulate the articulation dynamic?

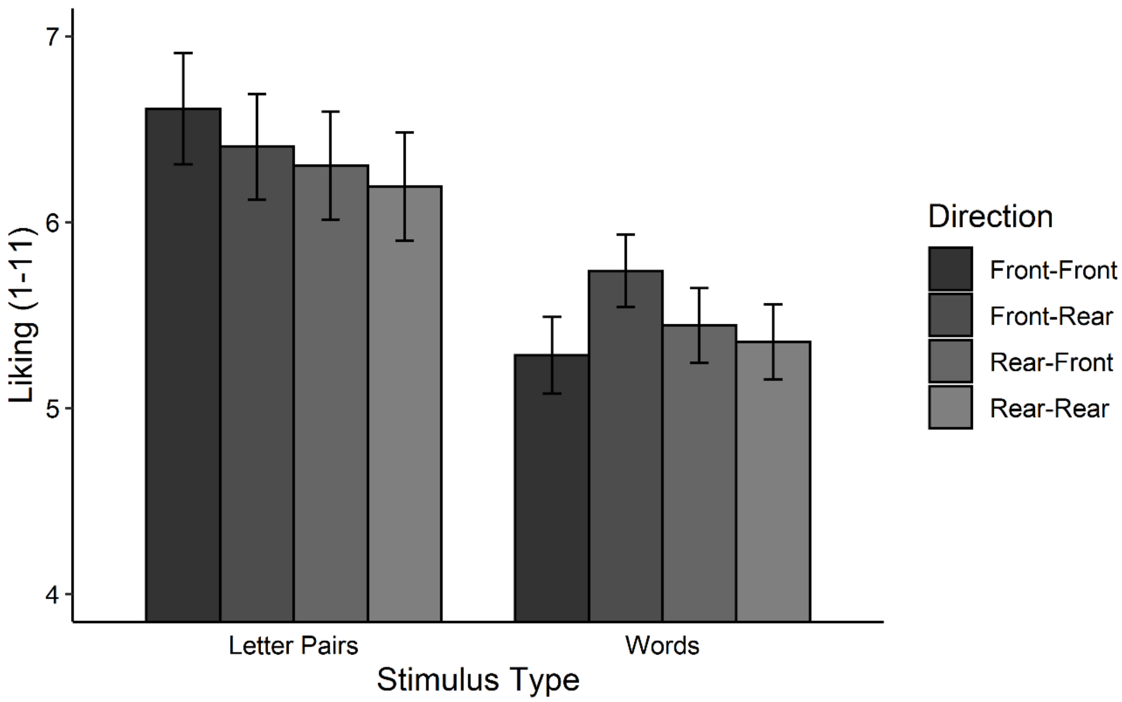
In case one of these determinants is not fulfilled, we predicted that stimulus evaluation is driven by amodal processing in the linguistic system, leading to an effect of consonant preferences (front-front > front-rear > rear-front > rear-rear, e.g., BODIMA > BODIKA > KODIBA > KODIGA). If both determinants are fulfilled, we predicted that stimulus evaluation is driven by modal processing in the simulation system, leading to an effect of articulation dynamic preferences (front-rear > rear-front & front-front = rear-rear, e.g., BODIKA > BODIMA = KODIGA > KODIBA).

I (together with Ira Maschmann and Tobias Vogel) tested these ideas in two experiments that have not yet been reported in a manuscript and are thus only briefly summarized here. Regarding a), we expected that consonant preferences drive stimulus preferences as long as the stimulus is not pronounceable. In German, pronounceability is primarily determined by the usage of vowels (Pompino-Marschall, 2009). Thus, I expected that in simple letter pairs without vowels (e.g., BK, KB), stimulus liking is driven by consonant preferences. However, adding a random vowel after each consonant should activate the modal simulation system, and thus the effect of consonant preferences should vanish. Instead, articulation dynamic preferences should drive stimulus liking.

I tested this idea in a simple experiment where some participants evaluated such letter pairs (e.g., BM, BK, KB, KG) and others evaluated the same letter pairs but with random vowels placed after each consonant (e.g., BEMA, BEKA, KEBA, KEGA). The results (N = 431) are displayed in Figure 6. A more detailed description of the methods can be found in the preregistration: https://osf.io/y9rw2/?view_only=0d524 f3b44ef4a86a1dd9abd33202a3e

Figure 6

Mean Stimulus Evaluation in Unpublished Data (N = 431)



Note. Error bars represent 95% confidence intervals.

The results for the letter pairs show the same pattern as in the data by Maschmann et al. (2020), suggesting an effect of consonant preferences on the liking of letter pairs. However, once vowels are added to the letter pairs, leading to pronounceable pseudowords, a different pattern emerges (see Figure 6). Inward (front-rear) words are preferred to outward (rear-front) words. However, in contrast to the findings in Ingendahl and Vogel (2022b), front-front and rear-rear stimuli receive evaluations below rear-front words. This deviation might come from the fact that no change of the consonantal articulation place is involved in these front-front and rear-rear words (e.g., BEMA, KEGA). Such words are simply harder to pronounce (Acheson & MacDonald, 2009). Recent research by Körner and Rummer (2021) shows very similar findings. Our findings show that vowel placement might indeed decide whether the modal simulation system becomes activated. Thus, previous research that relied heavily on mere letter pairs as stimuli most likely did not capture the intended concept of articulation dynamic preferences (Topolinski & Boecker, 2016a). For sure, replications of these studies with pronounceable stimuli should be conducted in the future.

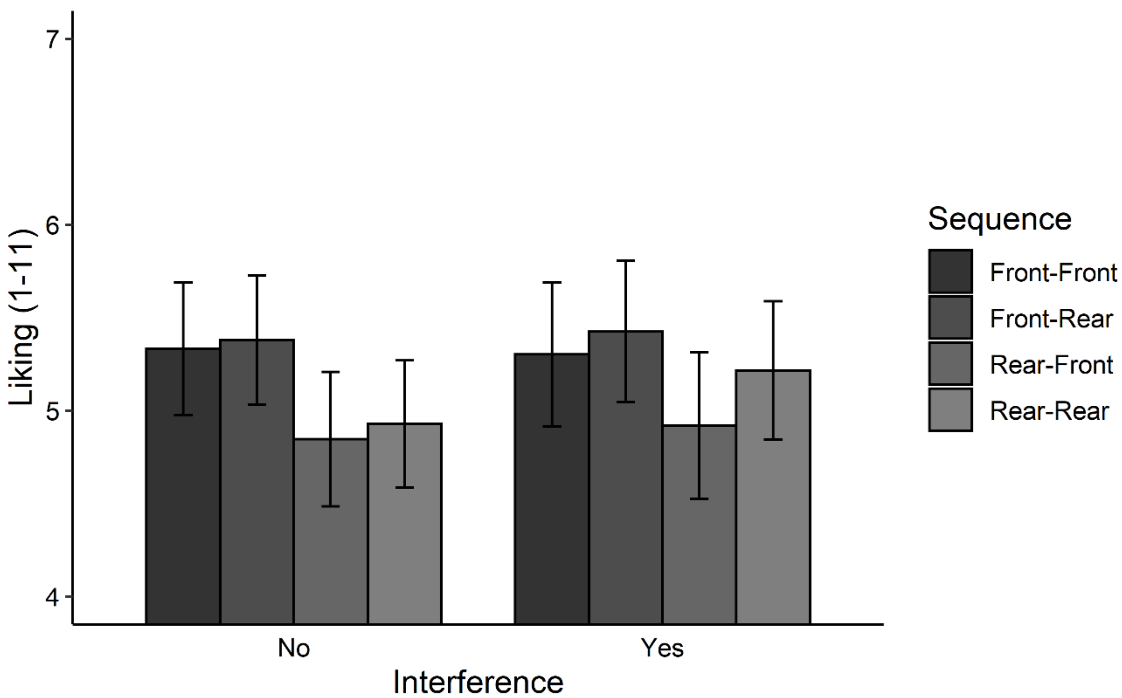
However, is it also possible to suppress the modal simulation system once it is activated? We aimed at testing this by reinvestigating the role of oral motor interference, as done by Lindau and Topolinski (2018a). To block motor simulations, Lindau and Topolinski let some participants whisper words, chew chewing gum, or move their tongue in a specific way while evaluating different inward/outward pseudowords. As mentioned in a previous section, they found no influence of any oral motor interference task on the in-out effect. Whereas these findings were puzzling to Lindau and Topolinski, they could, however, very well be explained by our integrative multi-system theory. If the modal simulation system is blocked by oral motor interference, stimulus liking is simply driven by the amodal system. For mere inward and outward words, one should thus expect the same empirical results independent of oral motor interference, despite being the result of different systems. Crucially, by extending the paradigm to front-front and rear-rear stimuli, one could easily identify whether amodal processing drives stimulus preferences under oral motor interference. Specifically, our dual system model would predict that under oral motor interference, the following pattern should occur even in the standard pseudoword evaluation task: front-front > front-rear (inward) > rear-front (outward) > rear-rear (e.g., BODIMA > BODIKA > KODIBA > KODIGA).

To test this, we conducted an extended replication of the research by Lindau and Topolinski (2018a). Specifically, we used the same co-occurrent whispering manipulation as Lindau and Topolinski but relied on the stimuli used by Ingendahl and Vogel (2022b). Again, a more detailed description of the methods can be found in the preregistration: https://osf.io/rxpj6/?view_only=2029cb740dab485bb726e842f0b129c9

The mean word evaluation (N = 184) is visualized in Figure 7. In contrast to our expectations, the pattern did not differ between the oral motor interference and the control participants. The results are similar to those of Ingendahl and Vogel (2022b) in both conditions. Descriptively, the effect of oral motor interference even goes in the opposite direction than expected.

Figure 7

Mean Stimulus Evaluation in Unpublished Data (N = 184)



Note. Error bars represent 95% confidence intervals.

These first findings speak against our dual system approach, unfortunately. Future studies with different oral motor interference manipulations should be conducted in the future to further test how the simulation system could be suppressed. As another idea, previous findings from embodied cognition research suggest that the linguistic system has its maximum activation peak before the simulation system (Barsalou et al., 2008). Thus, the linguistic system should be strengthened in a speeded word evaluation task, leading to a stronger impact of consonant preferences.

Overall, the findings from the two experiments suggest that vowel placement plays a crucial role in whether consonant preferences play a role or not in stimulus liking. However, our dual system approach is not supported by our findings. Thus, one could conclude at this point that

a) consonant preferences can potentially explain the in-out effect only in unpronounceable letter strings and word fragments, but
b) they cannot explain the in-out effect in the standard paradigm with pronounceable pseudowords.

Thus, the question arises what does *explain* the in-out effect for pseudowords? One answer was suggested by Bakhtiari et al. (2016) and will be discussed in the next section: Fluency.

Fluency

Ingendahl, M., Schöne, T., Wänke, M., & Vogel, T. (2021). Fluency in the in-out effect: The role of structural mere exposure effects. *Journal of Experimental Social Psychology*, *92*, 104079. https://doi.org/https://doi.org/10.1016/j.jesp.2020.104079

Ingendahl, M., Vogel, T., & Wänke, M. (2022). The Articulatory In-Out Effect: Driven by Articulation Fluency? *Journal of Experimental Social Psychology*, *99*, 104273. https://doi.org/10.1016/j.jesp.2021.104273

In the beginning of this dissertation, I discussed the link between sounds, language, and evaluative judgments, and as one prominent research area within this field, the research area of sound symbolism. Whereas sound symbolism research studies the influence of single phonemes within names (Sidhu & Pexman, 2018), another branch of research in social psychology has taken a more holistic approach. This research area investigates the influence of a name's pronounceability on (evaluative) judgments. For instance, surnames that are easy to pronounce (e.g., "Atkinson") are judged more positively than names that are hard to pronounce (e.g., "Leszczynska"; Laham et al., 2012). Anagrams that are easy to pronounce (e.g., "NOGAL") are also perceived as easier to solve than those difficult to pronounce (e.g., "AOSLR"), despite no actual correlation between solvability and pronunciation ease (Topolinski et al., 2016). In the consumer domain, food additives with hard-to-pronounce names are seen as more risky and harmful (Song & Schwarz, 2009)[12]. E-bay sellers are judged as more trustworthy if they have a short and easy-to-pronounce username (Silva et al., 2017)

[12] However, this finding seems difficult to generalize beyond specific materials (Bahník & Vranka, 2017).

which even generalizes to actual trust behavior in economic games (Zürn & Topolinski, 2017).

Such findings can be interpreted in the processing fluency framework. People have a general tendency to evaluate things more positively if they are easier to process or, in other words, have a higher *processing fluency* (Graf & Landwehr, 2015; Reber et al., 2004; Unkelbach & Greifeneder, 2013; Vogel & Wänke, 2016). Processing fluency can arise from a plethora of environmental factors, such as repeated exposure (Vogel et al., 2020; Wänke & Hansen, 2015), typicality (Vogel et al., 2021; Winkielman et al., 2006), contrast (Unkelbach, 2006), or in case of linguistic stimuli, ease of pronunciation or articulation (Alter & Oppenheimer, 2006; Bakhtiari et al., 2016; Körner et al., 2019; Laham et al., 2012).

There are two dominant explanations for why fluency leads to more positive evaluations. According to the hedonic fluency model (for a review, see Reber et al., 2004), the experience of fluency is inherently positive. “Mind at ease puts a smile on the face” (Winkielman & Cacioppo, 2001, p. 989); and this positive affect from fluency is misattributed to the respective stimulus, leading to a more positive evaluation. According to the ecological perspective (e.g., Corneille et al., 2020; Unkelbach, 2006, 2007; Unkelbach & Greifeneder, 2013), fluency itself is not inherently positive but a metacognitive cue people utilize in evaluative judgments. The interpretation of fluency and thus its effect on the evaluative judgment depends on the ecological correlation between fluency and valence in the respective context. As this correlation is positive in most contexts (Unkelbach et al., 2008), fluency will positively affect evaluative judgments in most contexts. However, both models agree that attributional processes and individual beliefs about the diagnosticity of the experience can change the effect of fluency on evaluative judgments.

Based on this broader framework, Bakhtiari and colleagues (2016) reasoned that the motor processes of inward *articulation* might be motorically more fluent compared to outward articulation, which leads to the in-out effect. From this perspective, the in-out effect is nothing more than a specific instantiation of a general principle already known – that fluency exerts liking. In that regard, the fluency account is conceptually similar to the consonant preference account that the in-out effect is caused by something that is not exclusive to inward/outward articulation. However, in contrast to the consonant preference account, the fluency account still relies on the original idea of inward/outward articulation dynamics[13].

In the following, I will briefly summarize the evidence supporting this articulation fluency account and the research I conducted with colleagues to test this account more critically (Ingendahl et al., 2021; Ingendahl, Vogel, & Wänke, 2022). I will begin with the correlative evidence in favor of the fluency account before I discuss the experimental evidence for the role of fluency.

Correlative Evidence: Liking, Fluency, and a Narrow Paradigm

In line with a fluency explanation, inward words are subjectively easier to articulate and objectively read faster than outward words (Bakhtiari et al., 2016; Körner et al., 2019; but see Lindau & Topolinski, 2018b, for different findings). Moreover, subjective articulation fluency judgments partially mediate the in-out effect (Bakhtiari et al., 2016). As an ecological correlate – and possibly even as an ecological explanation – of this fluency advantage, a corpus analysis on German and English words showed that front consonants are more common at word onset (compared to ending positions). In contrast, rear consonants are more common at ending positions (compared to word onsets) (Bakhtiari et al., 2016). This might lead to a higher prevalence of inward compared to outward articulation in natural language

[13] In that regard, the fluency account also implicitly assumes motor simulations. Otherwise, it would not be possible that articulation fluency is experienced even under silent reading.

and thus lead to the fluency advantage of inward words. However, all of these findings come along with specific problems:

First, the corpus analyses presented by Bakhtiari et al. (2016) are too vague to assess the prevalences of inward/outward sequences because they completely ignore the articulatory movements between the first and the last consonant. Furthermore, they do not capture the necessary statistical information. They report which position (onset/ending) is more typical for front/rear consonants, but not which consonant type (front/rear) is more typical for onset/ending positions. Technically, they assess the conditional probabilities p(onset|front consonant), p(ending|front consonant), etc., instead of p(front consonant|onset), p(front consonant|ending), etc., which should be predictive of the fluency of inward/outward patterns.

Second, the fact that inward words are more fluent than outward words does not mean that this fluency difference also explains differences in liking. The narrow paradigm used by Bakhtiari et al. (2016) with only inward and outward words is prone to false illusions of causality (e.g., Fiedler, 2017). As the in-out effect merely describes a difference in liking between these two word types, any other dependent variable that shows a similar difference between inward and outward words might seem a good “explanation” for the in-out effect. For instance, if inward words sound more “elvish” to us, one might intuitively assume that associations with Lord of the Rings mythology mediate the in-out effect.

Finding a partial mediation in such a design is also not surprising, due to the multiple problems of mediation analyses (Fiedler et al., 2011): The indirect effect in mediation is nothing more than the multiplication of the two regression coefficients a*b in the regression models

Fluency = a * Dynamic

and

Liking = b * Fluency + c * Dynamic.

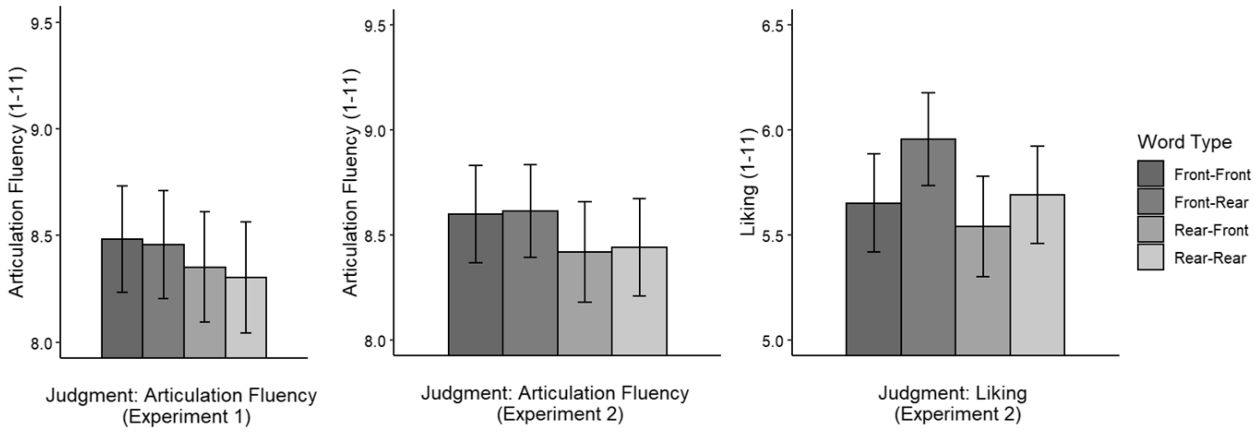
Given that liking and fluency have been shown to correlate highly in previous research, the b-path is almost certainly strong, leaving it up to the strength of the a-path whether an indirect effect emerges. In other words, if inward and outward words differ in articulation fluency, a partial mediation will occur, even if fluency is not the driving mechanism in the in-out effect.

To avoid such issues and test the fluency account more critically – which means making it easier to falsify – one could simply extend the standard in-out effect paradigm. One suitable way is to use the extended in-out effect paradigm with an orthogonal manipulation of the first and the last consonant as done by Ingendahl and Vogel (2022b). In this extended paradigm, front-rear (inward) words were liked more than rear-front (outward) words, with the mixed sequences front-front and rear-rear receiving average ratings. Based on the fluency account, the same pattern should occur when assessing articulation fluency instead of liking. That is, word types that differ in liking should show also differ in fluency, and word types that are equal in liking should also be equal in fluency. If, for instance, front-front words were as fluent as front-rear words but differed in liking (as found by Ingendahl & Vogel, 2022b), this would clearly show that mere articulation fluency cannot explain the overall differences in liking between different word types, including the in-out effect.

We thus conducted two experiments in this extended paradigm to test this fluency account more critically. Experiment 1 ($N = 201$) was an exact replication of Ingendahl and Vogel (2022b) but with a subjective articulation fluency measure instead of liking as the dependent variable. That is, participants were asked how easy it was to pronounce a specific word. Experiment 2 ($N = 330$) varied the judgment type between participants – fluency vs. liking. The results of both experiments are visualized in Figure 8.

Figure 8

Mean Liking Ratings in Experiment 1 (N = 201) and Mean Fluency Ratings in Experiment 2 (N = 330) of Ingendahl, Vogel, and Wänke (2022)



Note. Error bars represent 95% confidence intervals.

Both experiments show that front-rear (inward) words are indeed more fluent and more positive than rear-front (outward) words, thus replicating previous findings on the fluency account (Bakhtiari et al., 2016; Körner et al., 2019). Crucially, both experiments revealed that overall, fluency and liking diverged: Front-front words were equally fluent compared to front-rear words, despite being liked less[14]. These findings clearly show that articulation fluency *alone* cannot explain the in-out effect because inward words were liked more than front-front words but not easier to pronounce.

However, could fluency still play some role in the in-out effect? It could, when taking a different perspective on the in-out effect. Both Experiment 2 and the results from Ingendahl

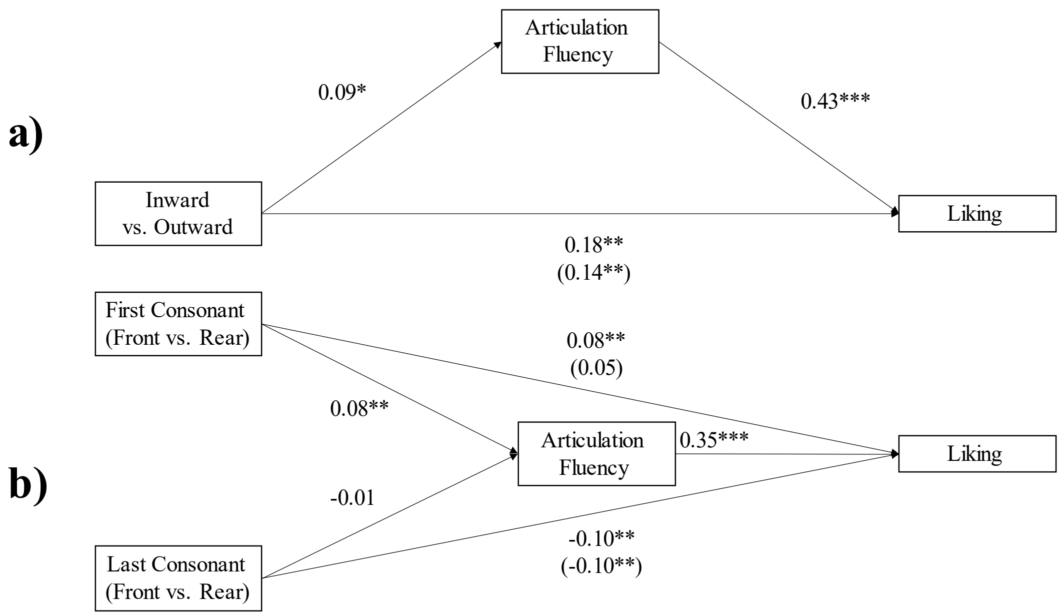
[14] For the difference between rear-rear and rear-front words, the results depended on the specific analysis strategy (i.e., Bayesian vs. Frequentist). However, the divergence of fluency and liking for front-front and front-rear words is sufficient to draw all conclusions discussed in the following paragraph.

and Vogel (2022b) suggest that the in-out effect can be dissected statistically into two additive effects: an effect of the first consonant (front > rear) and an effect of the last consonant (rear > front). Both effects contribute to the positive evaluation of inward words (first consonant front, last consonant rear) and lead to the negative evaluation of outward words (first consonant rear, last consonant front).

These two statistical main effects could also be interpreted theoretically such that two independent processes lead to the occurrence of the in-out effect. When considering the fluency pattern in both experiments (Figure 8), one can see that the effect of the first consonant is also present, but not the effect of the last consonant. Thus, at least the influence of the first consonant in the in-out effect might be attributable to articulation fluency. We tested this idea with a mediation analysis on the data of Experiment 2. Note that, of course, this mediation analysis cannot test a causal effect of fluency, but provides mere correlative evidence. The results of this mediation analysis are displayed in Figure 9. They show that fluency fully mediates the effect of the first consonant, but it does not mediate the effect of the last consonant. Thus, the "partial" mediation found by Bakhtiari et al. (2016) can be taken literally: Fluency mediates only a specific part of the in-out effect, namely the effect of the first consonant.

Figure 9

Mediation Analyses in Experiment 2 (N = 330 participants and N = 480 stimuli) of Ingendahl, Vogel, and Wänke (2022)



Note. * p < .05. ** p < .01. *** p < .001.

Note that these findings should be interpreted with caution for the following reasons: First, it remains open, which process leads to the effect of the last consonant. Second, even the causal role of articulation fluency in the effect of the first consonant yet has to be established. For instance, some studies show an in-out effect also when using stimuli without any frontal consonants (e.g., corona-dorsal letter strings such as DK vs. KD) (Topolinski & Boecker, 2016a), which cannot even partially be explained by a mere “front first is fluent” account. To further examine the role of fluency, experimental research might be necessary, which brings us to the general question of whether there is experimental evidence on the role of fluency in the in-out effect.

Experimental Evidence: Does Articulation Fluency Training Modulate the In-Out Effect?

In addition to the correlative findings by Bakhtiari et al. (2016), Körner and colleagues (2019) presented experimental studies on the fluency account. They reasoned that if indeed a higher prevalence of inward articulation in natural language leads to the fluency advantage of inward articulation (as discussed by Bakhtiari et al., 2016), then this "natural" training effect could be attenuated or reversed with *artificial* training of outward articulation. To test this, they let participants memorize and silently speak either inward or outward words in an artificial articulation training session. Afterward, they assessed the liking and fluency of inward/outward words. In line with their reasoning, artificial training of outward articulation attenuated or even reversed the in-out effect for liking and fluency judgments (Körner et al., 2019)[15].

Of course, exposing individuals to either inward or outward words in a training phase and measuring liking of words in a later test phase bears the risk of mere exposure effects. A mere exposure effect is an increase in liking due to mere repeated exposure to a stimulus (for reviews, see Bornstein, 1989; Montoya et al., 2017). To avoid this confound and to capture a pure training effect on the articulation dynamic, Körner and colleagues (2019) used different words in the training and the test phase. Moreover, in their last experiment, they even ensured that the test words did not even have the same syllables as the training words.

Yet, one additional confound cannot be excluded in their design: *structural* mere exposure effects on the specific *consonant sequences* (Folia & Petersson, 2014; Gordon & Holyoak, 1983; Kinder et al., 2003; Newell & Bright, 2001). For example, exposure to the

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[15] Note that this design cannot actually test whether the natural in-out effect is caused by fluency. It can only show whether artificial fluency trainings can overwrite the in-out effect and whether the in-out effect testing materials react to fluency manipulations.

word KODIBA can also increase the liking of KADUBI due to the repeated exposure to the consonant sequence K-D-B, despite being different words containing different syllables.

In two experiments, we tested whether this confound could indeed explain the results of Körner et al. (2019). We thus revised the training studies by Körner et al. (2019) while controlling for the stimulus structure of the training and the test words more thoroughly (Ingendahl et al., 2021). We followed the same procedure as Körner et al. (2019) with the same instructions and materials. However, we ensured that the test phase also contained inward/outward stimuli with consonant sequences that had not been used in the training phase. Specifically, the rating phase consisted of

a) words from the training phase (and their respective inward/outward counterpart),

b) inward/outward words constructed from the same consonant sequences as the training words, and

c) inward/outward words that were constructed from completely new consonants.

With these stimuli, we were able to differentiate between

a) mere exposure effects,

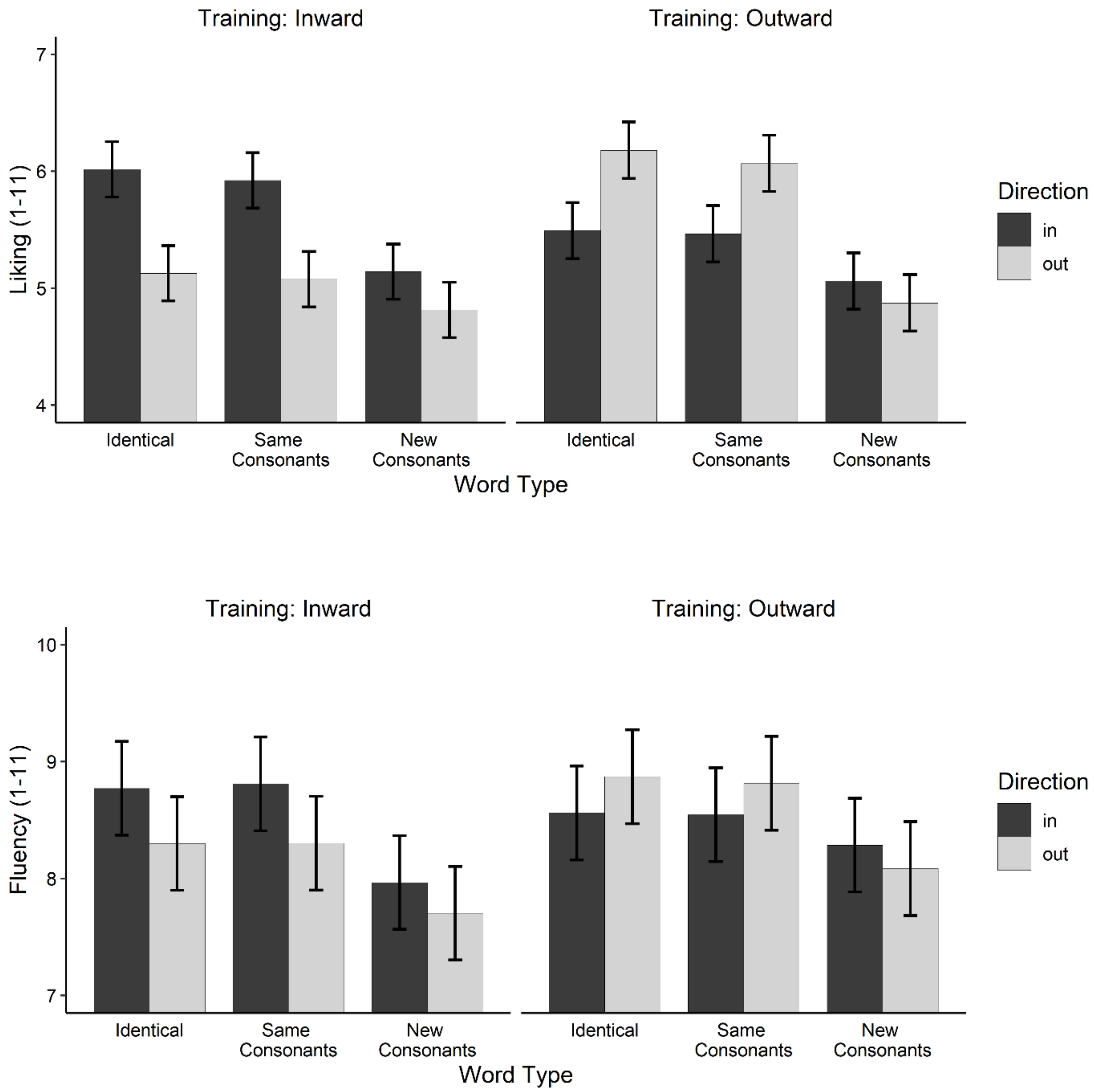
b) structural mere exposure effects, and

c) training effects on actual inward/outward dynamics.

Experiment 1 (N = 351) assessed word liking, Experiment 2 (N = 148) assessed articulation fluency in the test phase. The results are visualized in Figure 10.

Figure 10

Mean Liking Ratings in Experiment 1 (N = 351) and Mean Fluency Ratings in Experiment 2 (N = 148) in Ingendahl et al. (2021)



Note. Error bars represent 95% confidence intervals.

Our studies show a similar pattern as Körner et al. (2019) for the words that were identical to the ones from the training phase, but also for the words with the same consonant sequences as the words from the training phase: For these word types, training outward stimuli reversed the in-out effect. Crucially, no reversal or attenuation of the in-out effect was found for the words that contained new, untrained consonant sequences. Instead, inward words were more fluent and also more positive than outward words, independent of training. Thus, inward/outward articulation training does generalize to inward/outward dynamics, but only affects the specific consonant sequences that were used in the training session. What do these findings tell us?

To be clear, these findings do not falsify the fluency account. They merely imply that articulation fluency training as done by Körner et al. (2019) does not generalize on articulation dynamics but only benefits the specific consonant sequences in inward/outward stimuli. For these stimuli, mere exposure effects (training words) and structural mere exposure effects (same-consonant words) emerge. Thus, these findings question the experimental evidence presented by Körner et al. (2019) that aimed at showing a causal effect of fluency in the in-out effect. In other words, we do not falsify the fluency account but show that previous research on this account cannot be interpreted as evidence in support of it (if it can even be counted as evidence, see Footnote 15).

Beyond this, however, these findings further suggest important refinements of the fluency account: Whereas the generalized motor fluency of inward/outward movements remains untouched by artificial articulation fluency training, the structural fluency of single consonant sequences is altered. Thus, the fluency advantage of inward over outward stimuli might come not from the articulation fluency of inward/outward movements themselves, but by more specific and highly fluent articulatory patterns that appear predominantly in inward sequences (such as starting front consonants). Also, the fluency advantage of inward over outward words may be composed of two sources of fluency: First, there might be a mere biomechanical advantage of inward articulation (as suggested in previous research on language acquisition; MacNeilage & Davis, 2000). Second, in addition, some articulatory patterns of inward stimuli might be more frequent than others (Bakhtiari et al., 2016), which benefits these specific articulatory patterns, but does not influence the general biomechanical fluency advantage.

Interim Conclusion

In essence, both projects question the plausibility of the fluency account. Before I started with this research, the evidence for the fluency account seemed convincing with supporting correlative and experimental findings (Bakhtiari et al., 2016; Körner et al., 2019). However, after conducting both research projects on the fluency account, the evidence has shifted: The first project shows that articulation fluency alone definitely cannot explain the in-out effect, but it might still explain a part of it (specifically, the impact of the starting consonant). The second project shows that artificial fluency training cannot easily alter the fluency difference between inward/outward dynamics. Whereas the findings are mute about where the "natural" fluency advantage comes from – from a higher prevalence of inward articulation or a simple biomechanical advantage – they suggest that the motor fluency advantage for one consonant sequence does not easily generalize to others. Thus, even for the third account on the in-out effect, I have to conclude that it does not sufficiently explain the phenomenon.

General Discussion

In the previous sections, I presented a detailed overview of research on articulation dynamics and in particular the articulatory in-out effect (Topolinski et al., 2014). Overall, articulation dynamics have a robust influence on different judgments and decisions and have proven to do so in various languages and contexts. On the one hand, the empirical work summarized above further solidates the impression that the in-out effect is a robust phenomenon. Multiple high-powered and preregistered studies show a robust in-out effect, that is reduced neither by certain personality traits (Ingendahl & Vogel, 2022a), nor evaluative conditioning (Ingendahl, Maschmann, et al., 2022), nor articulation fluency training (Ingendahl et al., 2021). On the other hand, the presented research also clearly shows that we are much further from understanding the in-out effect than initially assumed.

When I began this dissertation project, three theoretical accounts were on the market – oral approach/avoidance, consonant preferences, and fluency – each with some supporting evidence and also (to a varying degree) mixed findings. The experiments summarized in the previous sections show that these accounts do not withstand more critical tests. Yet, one needs to differentiate here. The consonant preference account can be clearly dismissed based on our findings, at least for pronounceable stimuli. The fluency account in its strictest form can also be rejected; yet, it could be refined with an additional process explanation. The oral approach/avoidance account, however, cannot be falsified based on the current state of findings – but one might argue that the account is too vague to be falsifiable.

Overall, it seems that in-out effect research has reached a conceptual impasse where new theoretical perspectives are necessary. In that aspect, and beyond showing what is *not* behind it, the work summarized in this dissertation also provides further crucial insights into the in-out effect and the cognitive principles that must underly it:

First, the findings from two research projects clearly show that people do not think in the concepts “inward”/”outward”. Neither EC nor fluency training seems to generalize on inward/outward articulation dynamics (Ingendahl et al., 2021; Ingendahl, Maschmann, et al., 2022). Whereas previous research had already suggested that people do not have any explicit knowledge on articulation dynamics (e.g., they do not identify inward/outward dynamics as a system underlying the stimulus materials), our results suggest that there is also no implicit representation of inward/outward dynamics.

Second, most likely, different mechanisms contribute to the phenomenon. Our research on the consonant preference account shows that in some instances, evaluative judgments are perfectly consistent with consonant preferences, specifically if the stimulus is impoverished and unpronounceable. However, this changes once a stimulus contains vowels and thus becomes pronounceable (Ingendahl & Vogel, 2022b). Even if it is pronounceable, however, stimulus preferences are likely caused by multiple factors. For instance, articulation fluency might be relevant for the effect of the first consonant, but other processes must play a role in the effects of later consonants on stimulus liking (Ingendahl, Vogel, & Wänke, 2022).

With these things in mind, where should we start searching for such an overarching theory that can fully explain all the results from in-out effect research? As one possible first start, the projects summarized above suggest further investigations. For instance, one could pursue and further develop our idea on a dual-system account with modal and amodal processing. Also, one could continue our approach of two independent effects (first and last consonant). I discussed some ideas in the previous sections and thus do not go into further detail here.

However, I personally believe that in-out effect research might require larger breakthroughs than piece-by-piece theory building. From my impression, the in-out effect research has reached a stage where we are clearly missing something important. Thus, the research area needs to move again from *tightening* to *loosening* to gather fresh ideas. According to the creative cycle of science, research fields dynamically oscillate between these two stages (Fiedler, 2004, 2018). In the tightening stage, ideas are rigorously and critically tested. The experiments in this dissertation are critical tests for specific theories and can thus be counted as tightening. In the loosening stage, however, novel, risky, and unconventional endeavors are taken to explore new ideas. In the following, I briefly discuss some potential directions for future investigations that might help identify the processes underlying the in-out effect by *loosening* (which have in parts already been discussed in Ingendahl, Vogel, & Topolinski, 2022). These ideas focus on loosening in in-out effect research itself. Afterward, I will discuss conceptual problems of the research field from a meta-scientific perspective and suggestions for a broader scope of articulation dynamics research.

Directions for Future Research

First, despite the vast amount of research on the in-out effect that speaks for the context-independence of the phenomenon, it is of utmost importance to test the generalizability of the phenomenon systematically. The in-out effect has been investigated mostly in Indo-European languages with Latin script (specifically, German). There are only two notable exceptions where the effect has also been shown in another language family (i.e., Turkic) or script (i.e., Cyrillic; Godinho, Garrido, & Horchak, 2019). Replications in even more distant families and writing systems (such as in Chinese languages) might reveal the boundaries of the phenomenon. Suppose the in-out effect cannot be found in these language families. In that case, this suggests that differences between the language families (for instance, in the phonation system) should be investigated next. In contrast, a universal in-out effect implies a mechanism independent of the specific language family.

Second, future research must thoroughly assess the ecological correlates of inward/outward dynamics in natural language. As summarized in the previous section, the only published corpus analysis on the in-out effect provides only a very rough approximation[16] on the occurrence of inward/outward sequences in natural language (Bakhtiari et al., 2016). Beyond mere frequency, future corpus analyses should also investigate the ecological correlation of inward/outward dynamics in natural language with valence. Specific inward/outward sequences (or single consonants at specific positions) might be more/less positive to us because of their similarity with actual positive/negative words in natural language. Even though our experimental studies show that such associations do not easily generalize on inward/outward dynamics, they could contribute to the in-out effect in some instances (Ingendahl, Maschmann, et al., 2022).

Third, the robustness of the in-out effect across languages and individuals implies an early development in the course of life. However, this raises the question at which developmental stage the effect occurs. One could investigate the effect in samples of

a) Children of different ages. This would test whether the effect depends on specific cognitive developments (e.g., phoneme production, reading, writing).
b) Individuals who are deaf from birth. This would be a straightforward test of whether the effect is due to the sound of inward/outward phoneme combinations or whether the effect is independent of the specific sound of the phonemes.
c) Individuals who are blind from birth. This could show whether the effect is independent of an orthographic representation (i.e., the specific letter sequences in inward/outward stimuli).

Pertinent to the previous point, one study on aphasic patients (Topolinski et al., 2014) suggests that specific brain regions might play a crucial role in the in-out effect. Yet, our

[16] In defense of Bakhtiari et al. (2016) and also previous in-out effect research, one should note that corpus analyses are more complex than intuitively expected due to the uncountable exceptions of pronunciation in natural language (cf., Vaughan & O'Keeffe, 2015).

understanding of the neurological processes in the in-out effect is poor. Next to neuroimaging methods (e.g., fMRI), one could make use of transcranial magnetic stimulation techniques to suppress specific brain regions such as the motor cortex, the insula, or the Broca area (cf., Gianelli & Kühne, 2021). If the in-out effect is reduced while suppressing the motor cortex, for instance, this would suggest that mental simulations of articulation processes play a role in the phenomenon.

Additionally, whereas the in-out effect is usually embedded in the larger context of sound symbolism, it has rarely been investigated as such. Specifically, are inward/outward dynamics associated with specific semantic concepts which in turn influences stimulus liking? The oral approach/avoidance account postulates such an indirect effect on liking via the deglutition hypothesis (i.e., semantic associations with food ingestion), but these associations have only been measured once. In a recent study by Pathak et al. (2021), participants were actually more likely to associate sweet taste with outward than with inward words. As a side note, whenever I explain the in-out effect to friends and family members with exemplary inward/outward words, often they justify their evaluation in terms of "I prefer [word] because it reminds me of …". Thus, an exploratory approach that asks participants for their subjective associations with inward/outward stimuli might be the first step in detecting the concepts associated with inward/outward articulation.

Quo Vadis, In-Out Effect Research?

Last, and most importantly, I see one major conceptual challenge in in-out effect research that must be addressed and eventually overcome. This challenge is the phenomenon itself – the in-out "effect". In this dissertation, I defined the in-out effect empirically within the standard paradigm as a preference for stimuli with inward-oriented consonant sequences compared to stimuli with outward-oriented consonant sequences. This definition was rather phenomenological in order to include all previous research on inward/outward stimuli independent of the actual theoretical process assumed (e.g., preferences for inward articulation dynamics, consonant preferences, etc.). The results presented above suggest that such an empiricist definition is warranted here because the cognitive processes behind these results are far from understood. Yet, an “effect” is nothing more than the instantiation of different psychological processes and logically difficult to define in its scope. For instance, does the “effect” only refer to meaningless stimuli (e.g., pseudowords) or also to actual words? Is it restricted to specific assessment methods of evaluation (e.g., self-reports or indirect assessment)?

And moreover, why should we care about a difference in the evaluation of pseudowords or letter strings at all? The goal of psychology is to understand basic principles in human affect, cognition, and behavior. How does in-out effect research contribute to this overarching goal? Since the seminal publication of Topolinski et al. (2014), in-out effect research drifted away from investigating such a basic principle in human cognition – oral approach/avoidance induced by articulation dynamics – to investigating a difference in judgments on pseudowords. Whereas the differences in the liking of pseudowords were initially nothing more than one of the possible consequences of a psychological process, they have become the main focus of subsequent research. Moreover, this research relied on close replications within the very narrow paradigm of Topolinski et al. (2014) where inward and outward pseudowords are evaluated. For actual epistemic progress, deviation from the established paradigm is necessary (Fiedler, 2018; Fiedler et al., 2012). First progress can be seen in the studies by Maschmann et al. (2020) or our own work (Ingendahl, Vogel, & Wänke, 2022). For instance, our first project on the fluency account demonstrates how even a small deviation from an established paradigm, even if it only means to let participants rate other stimulus types, extends our knowledge on the in-out effect.

Thus, in which direction should in-out effect research go? I would suggest that in-out effect researchers should not completely abandon their natural habitat but continue their search for the processes underlying this intriguing phenomenon – for instance, by pursuing the ideas described in the previous section. While doing so, however, I would suggest moving beyond the scope of the in-out effect from time to time. This could reveal even more interesting insights into the interplay between language, sounds, and human cognition. Crucially, the theoretical accounts on the in-out effect offer plenty of starting points for moving beyond the in-out effect:

For instance, the general idea that articulation and food consumption share similar motor patterns and may thus be associated in mind deserves further consideration beyond an (arbitrary) difference in the evaluation of pseudowords. Thus, I would suggest investigating such associations outside a word evaluation paradigm, for instance, in an adapted implicit association test (Greenwald et al., 1998; see Parise & Spence, 2012 for a similar test procedure in sound symbolism research). In this IAT, participants are tasked to categorize pictures of food- and non-food objects as “food” or “no food” (of course, the picture sets need to be balanced in valence). Further, participants are tasked to categorize pseudowords that follow the rules of a language (e.g., BODIKA) and nonwords that do not follow the language (e.g., BDOKIA) as “words” or “nonwords”. Crucially, the pseudowords actually consist of three different word types: Pseudowords with an inward (e.g., BODIKA), with an outward (e.g., KODIBA), and no articulation dynamic (e.g., BOMIPA). If articulation dynamics are in any way associated with food-related motivational states, response times should be faster if participants have to respond with the same key to inward/outward words as for food pictures (versus non-food pictures).

Second, the consonant preference account makes one central assumption that is never explicitly mentioned, but actually of high relevance for the whole research area of language and evaluative judgments: People have to integrate different experiences from a linguistic stimulus into an overall impression. Different research areas with often very diverse theoretical backgrounds (e.g., social psychology, cognitive psychology, phonetics, (cognitive) linguistics, etc.) have studied what contributes to the liking of linguistic stimuli. These different research areas have focused mostly on specific effects in isolation – specific phonemes, fluency, or articulation dynamics. However, the studies presented in this dissertation suggest that the influence of each of these factors may vary – depending on the stimulus structure, and possibly even other factors. How do people integrate different experiences in such situations? As a first start, future research could take central moderators from the research of affective/cognitive feelings and judgments into account, such as the salience of an experience (e.g., do brands vary in articulation ease or in specific phonemes), or the relevance of an experience for a judgment (e.g., evaluation of a brand name or distinct taste expectations) (Greifeneder et al., 2010).

In this regard, previous studies have also treated fluency primarily as a single construct without differentiation of different fluency types (Bakhtiari et al., 2016; Laham et al., 2012; Song & Schwarz, 2009). Based on a large body of fluency research that shows essentially no differences in the effects of perceptual and conceptual fluency, this may seem justifiable (Oppenheimer, 2008; Reber et al., 2004; Unkelbach & Greifeneder, 2013). However, recent findings show that in environments with multiple sources of fluency, different types of fluency have a differential impact on different judgments (Vogel et al., 2020). In that regard, the motor fluency of articulation and the cognitive fluency of reading are, despited correlated in natural language, not the same (Goldrick, 2017): Some patterns can thus occur more frequently in natural language and thus foster word identification and lexical access, despite being difficult to pronounce. Based on the results of Vogel et al. (2020), I expect that these two types of fluency – articulation fluency and word processing fluency – have a differential impact on evaluative judgments depending on task affordances. Specifically, if participants expect that a specific brand name is communicated in oral form (e.g., via radio commercials), articulation fluency should have a stronger impact on brand name liking than if the brand name is communicated rather in written form (e.g., via newspaper advertisements).

However, these are only some future directions to illustrate where the theories and findings from in-out effect research could be relevant beyond the in-out effect itself. Other research areas, such as language production and comprehension, have also taken an interest in the in-out effect lately (MacDonald & Weiss, 2022), suggesting that the research area of articulation dynamics is likely to prosper further in the future.

Conclusion

The work summarized in this thesis shows that the in-out effect is indeed *robust* and *replicable*. However, it also shows that we are farther from understanding this effect than initially assumed. It almost seems that Martin Heidegger already had the in-out effect in mind when he wrote, *"Man acts as though he were the shaper and master of language, while in fact language remains the master of man."* (Heidegger, 1971, p. 144). Whereas people might be confident in why they like or dislike a specific word, they are not aware of the subtle influence of inward/outward articulation dynamics on their evaluations. And also, whereas researchers initially believed to master the in-out effect, it seems that the in-out effect masters the researchers.

However, in this dissertation, I also showed several possibilities for future research to further our knowledge on the in-out effect and the general interplay between language and evaluative judgments. Whether or not the influence of articulation dynamics on judgments and decisions is indeed *inexplicable* – future research will tell.

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Appendix

Appendix A: Co-Authors‘ Statements

Co-Author: Tobias Vogel

I hereby confirm that the following manuscripts included in the present thesis were primarily conceived and written by Moritz Ingendahl, PhD candidate at the Center for Doctoral Studies in Social and Behavioral Sciences of the Graduate School of Economic and Social Sciences at the University of Mannheim:

Ingendahl, M., & Vogel, T. (2022). Choosing a brand name that's "in" – disgust sensitivity, preference for intuition, and the articulatory in-out effect. *Personality and Individual Differences*, *185*, 111276. https://doi.org/10.1016/j.paid.2021.111276

Ingendahl, M., Maschmann, I. T., Embs, N. M., Maulbetsch, A., Vogel, T., & Wänke, M. (2022). *Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.* Manuscript in preparation.

Ingendahl, M., & Vogel, T. (2022). The articulatory in-out effect: Driven by consonant preferences? *Journal of Personality and Social Psychology*, *122*(2), e1–e10. https://doi.org/10.1037/pspa0000276

Ingendahl, M., Vogel, T., & Wänke, M. (2022). The Articulatory In-Out Effect: Driven by Articulation Fluency? *Journal of Experimental Social Psychology*, *99*, 104273. https://doi.org/10.1016/j.jesp.2021.104273

Ingendahl, M., Schöne, T., Wänke, M., & Vogel, T. (2021). Fluency in the in-out effect: The role of structural mere exposure effects. *Journal of Experimental Social Psychology*, *92*, 104079. https://doi.org/https://doi.org/10.1016/j.jesp.2020.104079

Ingendahl, M., Vogel, T., & Topolinski, S. (2022). The articulatory in-out effect: replicable, but inexplicable. *Trends in Cognitive Sciences*, *26*(1), 8–10. https://doi.org/https://doi.org/10.1016/j.tics.2021.10.008

I sign this statement to the effect that Moritz Ingendahl is credited as the primary source of the ideas and the main author of the above-mentioned articles. He came up with the ideas, designed the experiments, collected the data, performed the analyses, wrote the first drafts, and contributed to improving and revising the manuscript. I contributed to the research designs, structured the theoretical background and discussions of the manuscripts, revised the manuscripts, and provided recommendations for making the message of the articles clearer.

Prof. Dr. Tobias Vogel

Mannheim, March 2022

Co-Author: Ira Theresa Maschmann

I hereby confirm that the following manuscripts included in the present dissertation thesis were primarily conceived and written by Moritz Ingendahl, PhD candidate at the Center for Doctoral Studies in Social and Behavioral Sciences of the Graduate School of Economic and Social Sciences at the University of Mannheim:

Ingendahl, M., Maschmann, I. T., Embs, N. M., Maulbetsch, A., Vogel, T., & Wänke, M. (2022). *Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.* Manuscript in preparation.

I sign this statement to the effect that Moritz Ingendahl is credited as the primary source of the ideas and the main author of the above-mentioned article. He came up with the ideas, designed the experiments, collected the data, performed the analyses, wrote the first drafts, and contributed to improving and revising the manuscript. I contributed to the research design in Experiment 3, contributed to the theoretical background of the article, and revised the manuscript.

Ira Theresa Maschmann

Cologne, March 2022

Co-Author: Nina Embs

I hereby confirm that the following manuscripts included in the present dissertation thesis were primarily conceived and written by Moritz Ingendahl, PhD candidate at the Center for Doctoral Studies in Social and Behavioral Sciences of the Graduate School of Economic and Social Sciences at the University of Mannheim:

Ingendahl, M., Maschmann, I. T., Embs, N. M., Maulbetsch, A., Vogel, T., & Wänke, M. (2022). *Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.* Manuscript in preparation.

I sign this statement to the effect that Moritz Ingendahl is credited as the primary source of the ideas and the main author of the above-mentioned articles. He came up with the ideas, designed the experiments, collected the data, performed the analyses, wrote the first drafts, and contributed to improving and revising the manuscript. I contributed to the research design in Experiment 1, helped in crafting the study for Experiment 1, collected the data for Experiment 1, and gave feedback on the first manuscript draft.

Nina Embs

Mannheim, March 2022

Co-Author: Amelie Maulbetsch

I hereby confirm that the following manuscripts included in the present dissertation thesis were primarily conceived and written by Moritz Ingendahl, PhD candidate at the Center for Doctoral Studies in Social and Behavioral Sciences of the Graduate School of Economic and Social Sciences at the University of Mannheim:

Ingendahl, M., Maschmann, I. T., Embs, N. M., Maulbetsch, A., Vogel, T., & Wänke, M. (2022). *Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.* Manuscript in preparation.

I sign this statement to the effect that Moritz Ingendahl is credited as the primary source of the ideas and the main author of the above-mentioned articles. He came up with the ideas, designed the experiments, collected the data, performed the analyses, wrote the first drafts, and contributed to improving and revising the manuscript. I contributed to the research design in Experiment 2, helped in crafting the study, collected the data for Experiment 2, and gave feedback on the first manuscript draft.

Amelie Maulbetsch

Mannheim, March 2022

Co-Author: Michaela Wänke

I hereby confirm that the following manuscripts included in the present dissertation thesis were primarily conceived and written by Moritz Ingendahl, PhD candidate at the Center for Doctoral Studies in Social and Behavioral Sciences of the Graduate School of Economic and Social Sciences at the University of Mannheim:

Ingendahl, M., Vogel, T., & Wänke, M. (2022). The Articulatory In-Out Effect: Driven by Articulation Fluency? *Journal of Experimental Social Psychology*, *99*, 104273. https://doi.org/10.1016/j.jesp.2021.104273

Ingendahl, M., Maschmann, I. T., Embs, N. M., Maulbetsch, A., Vogel, T., & Wänke, M. (2022). *Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.* Manuscript in preparation.

Ingendahl, M., Schöne, T., Wänke, M., & Vogel, T. (2021). Fluency in the in-out effect: The role of structural mere exposure effects. *Journal of Experimental Social Psychology*, *92*, 104079. https://doi.org/https://doi.org/10.1016/j.jesp.2020.104079

I sign this statement to the effect that Moritz Ingendahl is credited as the primary source of the ideas and the main author of the above-mentioned articles. He came up with the ideas, designed the experiments, collected the data, performed the analyses, wrote the first drafts, and contributed to improving and revising the manuscripts. I contributed to the theoretical background and discussions of the manuscripts, revised the manuscripts, and provided recommendations for making the message of the articles clearer.

Prof. Dr. Michaela Wänke

Mannheim, March 2022

Co-Author: Tim Schöne

I hereby confirm that the following manuscripts included in the present dissertation thesis were primarily conceived and written by Moritz Ingendahl, PhD candidate at the Center for Doctoral Studies in Social and Behavioral Sciences of the Graduate School of Economic and Social Sciences at the University of Mannheim:

Ingendahl, M., Schöne, T., Wänke, M., & Vogel, T. (2021). Fluency in the in-out effect: The role of structural mere exposure effects. *Journal of Experimental Social Psychology*, *92*, 104079. https://doi.org/https://doi.org/10.1016/j.jesp.2020.104079

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Tim Schöne

Münster, 3rd March 2022

Co-Author: Sascha Topolinski

I hereby confirm that the following manuscripts included in the present dissertation thesis were primarily conceived and written by Moritz Ingendahl, PhD candidate at the Center for Doctoral Studies in Social and Behavioral Sciences of the Graduate School of Economic and Social Sciences at the University of Mannheim:

Ingendahl, M., Vogel, T., & Topolinski, S. (2022). The articulatory in-out effect: replicable, but inexplicable. *Trends in Cognitive Sciences*, *26*(1), 8–10. https://doi.org/https://doi.org/10.1016/j.tics.2021.10.008

I sign this statement to the effect that Moritz Ingendahl is credited as the main author of the above-mentioned article. He wrote the first draft and contributed to improving and revising the manuscript. I contributed to structuring the theoretical background and discussions of the manuscript, revised the manuscript, and provided recommendations for making the message of the article clearer.

Prof. Dr. Sascha Topolinski

Köln, March 2022

Appendix B: Manuscripts

In the following, all manuscripts are attached by the order of their referencing in this dissertation.

Personality and Individual Differences 185 (2022) 111276

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Choosing a brand name that's "in" – disgust sensitivity, preference for intuition, and the articulatory in-out effect

Moritz Ingendahl [a,*], Tobias Vogel [b]

[a] Department of Consumer and Economic Psychology, University of Mannheim, Germany
[b] Department of Social Sciences, Darmstadt University of Applied Sciences, Germany

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ABSTRACT

Words with an inward-wandering consonant sequence (e.g., MADIKO) are preferred to words with an outward-wandering consonant sequence (e.g., KADIMO), commonly referred to as articulatory in-out effect. Despite its robustness in consumer behavior across languages and settings, there has been no research on interindividual differences in this effect so far. Based on current theories on the phenomenon, we expect that the in-out effect should be moderated by interindividual differences in disgust sensitivity and preference for intuition. In a pre-registered, high-powered study ($N = 298$), we replicate the in-out effect in the domain of brand names. However, neither disgust sensitivity nor preference for intuition has a moderating influence. Our findings suggest that the in-out effect is likely to be observed across levels of these personality traits. We discuss further implications of these findings for the processes underlying the effect.

1. Introduction

Finding the perfect brand name is a delicate task. Brand names have a substantial influence on market success, and in some cases a brand name even decides over a brand's success or failure (Kohli & LaBahn, 1997). Thus, how should one name a new brand? The research field of sound symbolism has shown that phonetic aspects of a brand name convey product-related information (Klink, 2000): As an example, high vowels (e.g., i) are associated with little or light objects, whereas low vowels (e.g., o) are associated with large or heavy objects (Coulter & Coulter, 2010). Besides single phonemes, however, also the specific arrangement of phonemes plays a role for a brand name's success:

People prefer words with an inward-oriented consonant sequence over words with an outward-oriented consonant sequence, the so-called articulatory in-out effect (Topolinski et al., 2014). As an example, consider the fictional brand name MADIKO. Here, the [m] is formed with the lips, the [d] by touching the gums with the tongue, and finally the [k] with the rear back of the tongue. Thus, when articulating this brand name, the consonantal articulation spots constitute an inward movement. For the fictional brand name KADIMO, however, the consonants are reversed, leading to an outward movement. According to the in-out effect, and consistent with the empirical evidence, the inward name MADIKO is liked more than the outward name KADIMO (Topolinski et al., 2014). The effect can also be found for other names whose consonant letters[1] constitute a sequence of a front (e.g., B/M/P), a middle (e.g., T/D/L), and a rear (e.g., G/K/R) articulation spot (or the other way round).

1.1. The articulatory in-out effect in consumer behavior

Over the last years, a plethora of research has demonstrated the in-out effect's robustness across domains of consumer behavior (cf., Topolinski, 2017). Products labelled with inward names exert higher hedonic and utilitarian values, liking, purchase intentions, and willingness to pay, even if other product information is available (Godinho & Garrido, 2020; Topolinski et al., 2015). Food products are seen as more palatable if the dish is labelled with an inward name (Topolinski & Boecker, 2016), leading also to higher food consumption (Rossi et al., 2017). In the service domain, eBay sellers with an inward name are judged as more trustworthy and are eventually preferred as transaction partners (Silva & Topolinski, 2018). Overall, the in-out effect is very robust across languages and consumer judgments (cf., Ingendahl &

* Corresponding author at: A5,6 - B129, 68159 Mannheim, Germany.
E-mail address: mingenda@mail.uni-mannheim.de (M. Ingendahl).

[1] Note that these examples refer to German phonation. Depending on the specific language, consonant letters have different articulation spots. In English, for instance, the R is usually uttered as [ɹ], thus being produced in the middle of the mouth.

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Vogel, 2021; Topolinski, 2017). Thus, it should also occur when evaluating brand names:

H1. : Inward brand names are liked more than outward brand names.

Next to the effect's value for practical purposes, there is an active theoretical debate on its underlying processes: Several authors argue that the effect is caused by the similarity of inward articulation with motor movements of food ingestion (e.g., swallowing), and the similarity of outward articulation with motor movements of food expectoration (e.g., spitting; Topolinski et al., 2014). Food ingestion is positive whereas food expectoration is negative, and covert motor simulations induce these affective states while reading an inward/outward word. In support of this account, the in-out effect reverses for some products that trigger oral expectoration (e.g., bubble gum; Topolinski et al., 2017). However, the effect does not increase under food deprivation, speaking against this eating-related account (Maschmann et al., 2020).

Other researchers argue that the in-out effect is based on a higher fluency of inward articulation (Bakhtiari et al., 2016). Fluency elicits positive affect (Reber et al., 2004), which is then misattributed to the word. In support of this theory, inward names are indeed easier to articulate (Bakhtiari et al., 2016; Ingendahl et al., 2021) and fluency partially mediates the in-out effect (Bakhtiari et al., 2016). However, experimental studies have shown that training articulation fluency of inward/outward sequences does not influence the in-out effect (Ingendahl et al., 2021).

To conclude, despite its practical relevance the processes behind the in-out effect are still uncertain. However, previous research has focused exclusively on situational influences to test the two proposed mechanisms. Yet, the two accounts would also predict systematic interindividual differences in the in-out effect: To start with the eating-related account, the association of food ingestion with positive affect and food expectoration with negative affect is not universal, but varies between individuals (Olatunji et al., 2008). If affect associated with food consumption is indeed responsible for the in-out effect, then the size of the in-out effect should also vary between these individuals. Regarding the fluency account, some individuals have a stronger tendency to rely on affect and fluency in their judgments and decisions (Epstein et al., 1996). If affective experiences or fluency cause the in-out effect, these individuals should also show a stronger in-out effect.

In this research, we thus investigate interindividual differences in the in-out effect and their relationship with two personality traits – disgust sensitivity and preference for intuition. In the next sections, we will introduce these traits and explain how they relate to the proposed mechanisms behind the in-out effect. Examining the moderating influence of these traits does not only provide a new test for the mechanisms behind the in-out effect. For applied purposes, interindividual differences in the in-out effect also show whether inward brand names elicit higher liking for all individuals or whether inward brand names have no benefit when targeting certain types of consumers.

1.2. Disgust sensitivity

Disgust sensitivity can be described as the "general tendency to respond with the emotion of disgust to any given situation" (van Overveld et al., 2006, p. 1412). The emotion of disgust itself is a rejection response focused on eating, thus an oral defense mechanism (Haidt et al., 1994). Disgust sensitivity is an increasingly prominent construct in consumer research because it predicts different food-related consumer behaviors, such as variety seeking, picky eating, food waste, and the acceptance of novel or existing food technologies (Egolf et al., 2018; Siegrist et al., 2020).

However, disgust sensitivity is also a promising construct in our research if we consider the eating-related account on the in-out effect: For consumers with higher disgust sensitivity expectorating food is inherently more negative than for individuals with low disgust sensitivity (Olatunji et al., 2008). Correspondingly, they are also more afraid of vomiting (van Overveld et al., 2008). As the eating-related account assumes that outward articulation resembles food expectoration movements, outward words should elicit more negative affect for consumers with high disgust sensitivity, leading to a stronger in-out effect.

From an alternative perspective, consumers with higher disgust sensitivity are also more prone to experience disgust at food intake (Ammann et al., 2018). As the eating-related account assumes that inward articulation resembles movements of food intake, consumers with higher disgust sensitivity might also experience less positive affect from an inward movement. Thus, disgust sensitivity might also moderate the in-out effect in the opposite direction, such that the effect is weaker for consumers with higher disgust sensitivity. Both moderations are possible according to the eating-related account, thus we expect a moderation without specifying the direction a priori:

H2. : The in-out effect as postulated in H1 is moderated by disgust sensitivity.

Crucially, this effect would only be predicted by the eating-related account, but not by the fluency account, providing a good opportunity to contrast the theories.

1.3. Preference for intuition

Consumer decisions are influenced by two different types of information processing – intuitive and rational thinking (e.g., Epstein et al., 1996; Kahneman, 2011; Novak & Hoffman, 2009): Intuitive processing is seen as fast, affect-based, automatic, and holistic, whereas rational thinking is considered to be slow, deliberative, and rule-based. Notably, consumers also differ in their habitual preference for engaging in these thinking styles (Betsch, 2004; Epstein et al., 1996). Thus, consumers with a higher preference for intuition are generally more likely to use affect and gut feeling when making a judgment (Betsch, 2008; Richetin et al., 2007). Accordingly, they also rely more on affective experiences in their evaluations (van Giesen et al., 2015).

This implies that consumers with a high preference for intuition should also rely more strongly on their intuition when evaluating inward vs. outward brand names: Both the eating-related account, and the fluency account, presume that inward movements elicit positive affect and outward movements negative affect. Consumers with higher preference for intuition are thus more likely to use this affect to evaluate inward and outward brand names. In fact, the fluency account in particular would predict a strengthened in-out effect for such individuals because the experience of fluency is a core driving mechanism behind intuitive judgments (Topolinski & Strack, 2009). Thus, we expect:

H3. : The in-out effect as postulated in H1 is strengthened by preference for intuition.

To test our hypotheses, we conducted an online study where we let participant evaluate fictional inward and outward brand names and assess both personality traits.

We preregistered our hypotheses, design, and analysis on the OSF: https://doi.org/10.17605/OSF.IO/EG58Q. All code and data are provided in this OSF directory: https://doi.org/10.17605/OSF.IO/TFDBJ.

2. Methods

2.1. Design & procedure

This study followed a within-subjects design with the factor direction of a brand name (inward vs. outward) and the continuous between-subjects variables disgust sensitivity and preference for intuition. Participants were recruited via Prolific Academic to answer a short online survey of eight minutes for 0.91£ (6.83£/h) compensation. After giving informed consent, participants were told that this study investigated preferences for new brand names. Next, participants evaluated 54 fictional brand names (27 inward and 27 outward) in random order and provided sociodemographic data. Afterwards, personality traits were assessed. Finally, participants were asked about the study purpose and whether they identified a system behind the words before they were thanked, debriefed, and dismissed.

2.2. Materials

2.2.1. Brand names

We generated brand names from the front consonant letters B/P/M, the middle consonant letters D/T/L, the rear consonant letters G/K/R, and the vowels A/E/I/O/U. The same letters have been used in previous research on the in-out effect with German-speaking samples (Ingendahl & Vogel, 2021; Maschmann et al., 2020; Topolinski et al., 2014). We randomly generated names for each participant to avoid systematic confounds. Thus, following the procedure of Ingendahl et al. (2021), the names were constructed ad-hoc from the 3 × 3 × 3 consonants, leading to overall 27 inward and 27 outward names. Each word consisted of a sequence of three consonants (e.g., B-D-K, for inward, K-D-B for outward), and random vowels were added after each consonant (e.g., inward: BODIKA, MALUGI, …; outward: KEDOBU, GILAME, …).[2] Sample stimuli are provided in the online supplement. Brand name liking was assessed by presenting each brand name on a single slide with the question “How much do you like this brand name?” and a rating scale from 1 (I do not like it at all) to 11 (I like it very much).

2.2.2. Personality measures

Preference for Intuition was assessed with the 9-item PFI scale by Betsch (2004), with a response scale from 1 to 7. One exemplary item is “My feelings play an important role in my decisions”. Disgust Sensitivity was assessed with the 37-item questionnaire for the assessment of disgust sensitivity (QADS; Petrowski et al., 2010; Schienle et al., 2002): Participants received several situation descriptions and indicated how disgusting these situations are on a scale from 1 to 5. Next to an overall score, the QADS items can additionally be combined to three subscales (Petrowski et al., 2010): Core Disgust (e.g., “You smell spoiled food.”), Animal Reminder Disgust (e.g., “During a walk in the woods, you see a decomposing animal.”), and Contamination Disgust (e.g., “You accidentally touch the toilet seat in a public restroom.”). Both PFI and QADS are well-established and reliable measures that were validated in German language. Descriptive statistics, internal consistencies, and correlations are provided in Table 1.

2.3. Power & participants

As a rough approximation for our planned analysis, we conducted an a priori power analysis in G*Power (Faul et al., 2007) in the within-between interaction interface, with two groups (personality trait high/low) and two measurements (inward/outward). Assuming a small effect size, $f = 0.10$, and $\alpha = 0.05$, a sample size of $N = 266$ was necessary to have 90% statistical power. The same sample size was necessary to replicate a small in-out effect in our design. Thus, we aimed at a sample size of $N = 300$. To make sure that consonant letters had the same articulation spots for all participants (i.e., G is ambiguous in English), we collected data exclusively from native Germans. Our sample consisted of 301 native Germans (171 male, 125 female, 5 diverse, $M_{age} = 31.44$, $SD_{age} = 10.96$, Range$_{age}$ [18; 69], 34% students). Thus, despite not being representative, the sample was heterogeneous regarding basic demographic information. Following the preregistration protocol, we checked whether participants had to be excluded because of redundant answering (>50/54 times the same answer), which was not the case. However, three participants referred to articulation movements via consonant order when asked about the study purpose or the systematics behind the names. They were excluded from all analyses.

Table 1
Intercorrelations, internal consistencies (main diagonal), and descriptive statistics of all personality variables (N = 298).

	1. PFI	2. QADS	3. $QADS_{CORE}$	4. $QADS_{ARD}$	5. $QADS_{CONT}$
1	(0.86)	0.17	0.16	0.13	0.14
2		(0.92)	0.92	0.79	0.90
3			(0.83)	0.57	0.79
4				(0.84)	0.54
5					(0.80)
M	4.53	3.24	3.82	2.53	3.07
SD	1.02	0.59	0.59	0.82	0.67

Note. All correlations are significant at $p < .05$. CORE = core disgust, ARD = animal reminder disgust, CONT = contamination disgust.

3. Results

All code for our analysis is provided in the OSF directory. Due to the nested data structure with measurements nested in participants, we ran a multilevel regression in the lme4 package (Bates et al., 2019). Our level-1 predictor direction was effect-coded (1 = inward, −1 = outward). On level 2, we added the z-standardized PFI and QADS values. Our model contained random intercepts for participants ($SD = 1.21$) and random slopes for the direction effect ($SD = 0.33$).

As expected from H1, inward brand names were liked more than outward brand names, $b = 0.27$, $t(295) = 11.20$, $p < .001$, $d_z = 0.65$. However, neither PFI, $b = 0.02$, $t(295) = 0.98$, $p = .327$, nor disgust sensitivity, $b = 0.02$, $t(295) = 0.86$, $p = .392$, had a significant moderating influence on the inward-outward difference. Thus, the in-out effect was not significantly different across different levels of PFI or disgust sensitivity, supporting neither H2, nor H3. The main effects of PFI, $b = 0.06$, $t(295) = 0.78$, $p = .435$, and disgust sensitivity, $b = -0.09$, $t(295) = -1.24$, $p = .217$, were not significant, either. These results are visualized in Fig. 1. Following the preregistration protocol, we repeated the analysis with each personality trait in a separate model. Additionally, we investigated effects for the three QADS subscales in further separate models. These models led to very similar results which are thus not reported here, but can be found in our OSF directory.[3]

To further quantify the null evidence, we conducted a Bayesian test with the BayesFactor package (Morey & Rouder, 2018) and default priors on the correlation between the in-out difference within a participant and the respective personality trait. For both PFI, $r = 0.07$, $BF_{10} = 0.25$, and disgust sensitivity, $r = 0.06$, $BF_{10} = 0.23$, the data provide moderate support for the null hypothesis.

4. General discussion

People prefer words with an inward compared to words with an

[2] This random word generation leads to some words that are similar to existing German words (e.g., “BATERI”). To control for this (see also Ingendahl & Vogel, 2021, for a similar approach), we repeated the main analysis without these words (overall 12). As the results were nearly identical, we do not present these results here, but the analyses can be found in the OSF directory. Due to a coding error, some consonant sequences occurred twice within participants, but with different vowels. However, this error affected inward and outward words in the same way and thus does not change the interpretation of the findings. Also, the results do not change when excluding such trials.

[3] Based on a suggestion from an anonymous reviewer, we repeated the analyses with additional three-way interaction terms to see whether one personality variable influences the moderating impact of the other one. This was not the case, the analyses can be found in the OSF directory.

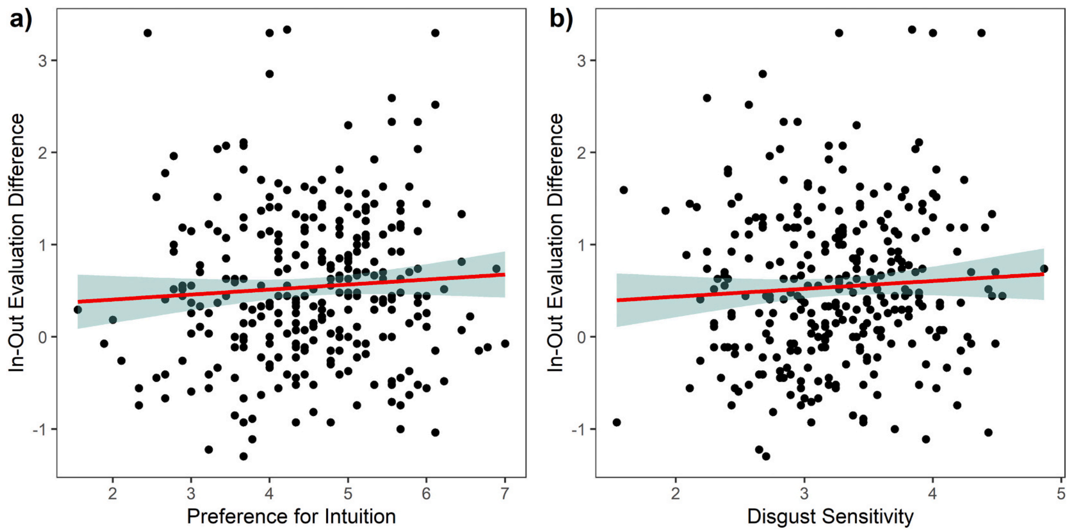

Fig. 1. Evaluation of inward vs. outward brand names by personality (N = 298). Note. Shaded areas represent 95% confidence intervals.

outward consonant sequence, referred to as articulatory in-out effect (Topolinski et al., 2014). Whereas the effect's robustness has been shown in different domains of consumer behavior (cf., Topolinski, 2017), the theoretical processes are still on debate. Based on previous theoretical accounts, we expected interindividual differences in the in-out effect which should relate to two specific personality traits: disgust sensitivity and preference for intuition. In our highly powered preregistered study ($N = 298$), we find a clear in-out effect: Brands with an inward name are liked more than brands with an outward name (H1). However, we see no moderating influence of either of the personality traits on the in-out effect (H2 + H3). In the following, we will first discuss theoretical and managerial implications of our findings, and then limitations of our research.

4.1. Theoretical implications

First, the absence of any moderating influence of disgust sensitivity questions the plausibility of the eating-related account: If the in-out effect is based on the similarity of inward/outward movements with food consumption, interindividual differences in the association of food consumption with affect should correlate with interindividual differences in the in-out effect. Thus, disgust sensitivity should have moderated the effect. This was not the case, not even when using the subscale core disgust that explicitly captures eating-related disgust sensitivity. Our findings fit to recent experiments conducted by Maschmann et al. (2020) showing that the in-out effect is also resistant against experimental disgust induction. While these findings substantiate that the in-out effect is not explained by an association of outward movements and avoidance behaviors, they do not necessarily rule out the opposite, that is inward movements are associated with an approach tendency. Indeed, individuals with high disgust sensitivity still experience positive affect while eating (e.g., Schienle & Wabnegger, 2021), after all. Even if the disliking of outward movements contributes to the overall effect, the association of inward movements with eating-related approach states might be too strong and universal (Topolinski et al., 2014), so individual differences in disgust sensitivity cannot moderate the overall effect.

Second, the absence of any moderating influence of preference for intuition is inconsistent with both the eating-related account and the fluency account. If inward movements elicit positive affect – either by associations with food intake or by a higher fluency – individuals with higher preference for intuition should be more prone to use this affect when evaluating brand names (Betsch, 2004, 2008). This was also not the case in our study, which is in line with recent evidence that the different fluency of inward and outward words may not necessarily be the cause of the in-out effect (Ingendahl et al., 2021).

Overall, we do not find any support for both accounts in our data, which contributes to the current debate on the underlying processes and implies that further theorizing on the in-out effect is necessary. By the same token, our findings show how robust and hard-wired the mechanisms must be that drive the in-out effect.

4.2. Managerial implications

Whereas our findings question the theoretical accounts on the in-out effect, they actually offer valuable insights for marketers and brand managers: Not only does an inward brand name increase liking for the brand, this benefit of an inward name works consistently across different individuals. That is, marketers do not need to worry that their inward brand name backfires for specific consumers, e.g. those with a high disgust sensitivity. Especially for brands in disgust-related domains (e.g., hygiene products) this might be good news. In addition, even for consumers with less intuitive decision behavior an inward name will still elicit higher liking of a brand. Thus, a clear implication of this research is to use an inward name when emitting a new brand as it elicits more liking across different consumers. Furthermore, there is clear evidence for revenue benefits of fluency (Alter & Oppenheimer, 2006) and also of inward sequences in names (Topolinski, 2017). Our findings indicate that both are independent influences, thus implying that both articulation directions and fluency could be combined to further increase brand liking.

4.3. Limitations

Finally, there are also limitations of our research. First, brand names were generated randomly, which increases internal validity while at the same time it reduces control over the brand names. As an example, some names might have reminded participants of the valence of natural words. However, we also repeated the analysis after excluding all words similar to existing German words, which led to the same results. Second, we did not explicitly instruct participants to read the brand names out aloud. Even though the in-out effect also occurs when active articulation is prevented (Lindau & Topolinski, 2018), this might have attenuated the influence of personality, in particular disgust sensitivity. Third, we conducted a single study with a broad, but not representative sample of German native speakers. Despite being sufficiently powered, the moderating influence of personality might be very small. Thus, future studies should aim at replicating our findings. For that purpose, they might also use different measures and samples.

Last, our investigation was limited to only two traits, disgust sensitivity and preference for intuition. While the consideration of these specific traits logically followed from theorizing on the in-out effect, it would be premature to reject the systematic influence of other personality traits all together. In fact, the mixed evidence on previous theorizing calls for novel explanations and a moderation by other personality traits may help generating a new theoretical account.

4.4. Conclusion

Once again, the articulatory in-out effect has proven to have a very robust influence on the liking for a brand name. Our results show that it is not moderated by disgust sensitivity or preference for intuition. This contributes to the current theoretical debate on the processes underlying the in-out effect and shows that further theorizing is necessary.

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CRediT authorship contribution statement

Moritz Ingendahl: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Visualization, Project administration, Funding acquisition. **Tobias Vogel:** Conceptualization, Writing – review & editing.

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TITLE: Do we know what's in and what's out? No generalized representation underlying inward and outward articulation dynamics.

Abstract

People prefer linguistic stimuli with an inward (e.g., BODIKA) over those with an outward articulation dynamic (e.g., KODIBA), a phenomenon referred to as articulatory in-out effect. Despite its robustness across languages and contexts, the cognitive processes behind this effect are still at debate. In the present research, we examine whether people have a generalized representation of inward and outward articulation dynamics independent of the specific consonant sequences in the stimuli. In three experiments (N = 420, two experiments pre-registered) with an evaluative conditioning procedure, we systematically paired words with inward versus outward dynamics with pictures of positive versus negative valence. Although this evaluative conditioning procedure attenuated or even reversed the in-out effect, this modulation only occurred for words with the same consonant sequences as the conditioned words. For words with inward/outward dynamics but different consonant sequences than the conditioned ones, no moderation of the in-out effect was found. These findings suggest that people do not have a generalized representation of inward/outward dynamics. Further implications for in-out effect research and evaluative conditioning are discussed.

Keywords: in-out effect, articulation dynamics, language, evaluative conditioning, generalization

Which word do you like more – BODIKA or KODIBA? Research on the articulatory in-out effect would predict that it is most likely BODIKA (Topolinski et al., 2014). This effect describes a systematic preference for linguistic stimuli with an inward articulation dynamic over stimuli with an outward articulation dynamic. In BODIKA, the first consonant [b] is formed at the front of the oral cavity (labial), the second consonant [d] in the middle (coronal), and the last [k] at the back of the mouth (dorsal), constituting an inward dynamic when articulating the word. In KODIBA, this sequence is reversed (dorsal-coronal-labial), forming an outward dynamic. Within the articulation system of a given language, different consonant letters have consistent and specific places of articulation, and thereby words can be formed that elicit such inward/outward dynamics. In English, for instance, inward/outward stimuli can be constructed from the letters B, P, M, F to elicit labial articulation, the letters D, T, L, N, S to elicit coronal articulation, and the K to elicit dorsal articulation. In German, the letters G and R can also be used to produce dorsal articulation, leading to preferences for inward words such as MENURO or PATUGI, compared to outward words such as RENUMO or GATUPI.

The in-out effect is empirically very robust (for reviews, see Ingendahl, Vogel, & Topolinski, 2022; Topolinski, 2017). It emerges across different languages such as English, German (Topolinski et al., 2014), Portuguese (Godinho & Garrido, 2016), Ukrainian, and Turkish (Godinho, Garrido, & Horchak, 2019). It occurs both under silent reading and when merely listening to a speaker, even for abstract letter strings such as consonant pairs (e.g., BK vs. KB; Topolinski & Boecker, 2016a) or word fragments (e.g., B _ _ _ K _ vs. K _ _ _ B _; Maschmann et al., 2020). Furthermore, even short presentation times as low as 50ms (Gerten & Topolinski, 2018) and the suppression of subvocalizations (e.g., via concurrent whispering; Lindau & Topolinski, 2018) do not harm the effect. Not only is the effect remarkably robust under laboratory conditions, it also bears consequences for applied contexts: For instance, people with inward names are judged as warmer, E-bay sellers with inward names as more trustworthy, and food labeled with inward names as tastier (Garrido et al., 2019; Silva & Topolinski, 2018; Topolinski & Boecker, 2016b).

Due to the effect's robustness across languages and contexts, there is a heated debate on its underlying processes (Ingendahl, Vogel, & Topolinski, 2022; Ingendahl & Vogel, 2022b; Körner & Rummer, 2021; Maschmann et al., 2020). This debate has gone so far that some researchers have begun questioning the core concept behind the in-out effect – that the effect is about inward/outward articulation dynamics at all (Ingendahl, Vogel, & Wänke, 2022; Maschmann et al., 2020). In a recent review, Ingendahl et al. (2022) summarize the effect as "replicable, but also inexplicable" and call out for new theoretical perspectives on what might be behind this phenomenon.

To do so, the present work targets a central cornerstone that has not received much attention so far: the representation underlying inward/outward dynamics. Specifically, we examine whether people have a generalized representation of inward/outward dynamics independent of the specific consonant sequences within the stimuli. As an illustration for such a generalized representation, consider the introductory examples of the two inward words BODIKA and MENURO. Except for the same three-syllable consonant-vowel structure, they share neither phonetic nor orthographic features. Both words consist of entirely different consonant (and vowel) sequences. From this perspective, the inward word BODIKA is as (dis-) similar to the inward word MENURO as to the outward word RENUMO. However, BODIKA and MENURO (in contrast to RENUMO) share the same inward articulation dynamic that starts with a labial, continues with a coronal, and ends with a dorsal place of articulation. Thus, from this perspective, BODIKA is more similar to MENURO than to RENUMO.

The question, which we address here, is whether stimulus words such as BODIKA and MENURO are represented as following an inward dynamic when people form an evaluative judgment towards these words. This does not imply a conscious categorization of words into their articulation dynamic, but that some stage in the processing of these words marks them as inward/outward. As we elaborate in the next section, previous theories on the in-out effect make different assumptions on whether preferences for inward over outward dynamics require such a generalized representation of articulation dynamics independent of the specific consonant sequences. Thus, investigating the representation provides a good opportunity also to contrast these theories against each other.

Articulation Dynamics, Food Consumption, and Motor Simulation

Initially, the in-out effect was conceived as an instance of oral approach/avoidance induced by articulation dynamics (Topolinski et al., 2014). This oral approach/avoidance account rests on the observation that the motor-mouth movements of inward/outward articulation are similar to those of consuming food or drinks. Specifically, inward articulation resembles food ingestion (e.g., swallowing), whereas outward articulation resembles food expectoration (e.g., spitting or vomiting). Because food ingestion comes with positive affect, but food expectoration with negative affect, inward/outward articulation dynamics should elicit positive/negative affective states as well. Specifically, once an inward/outward word is read, the inward/outward dynamic was expected to be motorically simulated (i.e., via subvocalization), activating associated affective states and thereby influencing stimulus liking (Godinho, Garrido, Zürn, et al., 2019; Topolinski et al., 2014; Topolinski & Bakhtiari, 2016).

This oral approach/avoidance account would predict that a stimulus must be represented as following an inward or outward dynamic to influence evaluative judgments. This does not mean that the stimulus is deliberately classified as being inward/outward but that there is a cognitive process that

a) first extracts the different articulation places of the consonants, and
b) then combines them into a sequence that is motorically simulated and experienced as an inward/outward dynamic.

This representation of inward/outward dynamics is associated with positive/negative valence, influencing stimulus liking. For instance, in the word BODIKA the different places of articulation must first be extracted (e.g., "[b] = labial, [d] = coronal, [k] = dorsal"). These places of articulation must be represented and experienced as a dynamic moving inward, leading to a positive evaluation of the word.

The idea that word material is represented in an *articulatory motorial code* is not entirely new. Early research on short-term memory proposed that the mental rehearsal of words involves a representation based on the physical articulation movements of the stimuli (Hintzman, 1967). However, later studies did not support such reasoning (Wickelgren, 1969; but see Schweppe et al., 2011). Instead, prominent working memory models merely propose a *phonological code* (Baddeley & Logie, 1999). Another stream of research supporting the idea of generalized representations of inward/outward articulation dynamics is the embodied cognition literature (Barsalou, 2007). According to the *embodied language processing framework* (Gianelli & Kühne, 2021), language comprehension does not only operate in an abstract/amodal processing manner but also incorporates sensorimotor information. For example, skilled (but not novice) typists prefer letter combinations that can be typed with different fingers (vs. the same finger). This preference vanishes if motor simulations are suppressed by a secondary task (Beilock & Holt, 2007). In a similar vein, interfering with subvocalizations by oral motor tasks, such as chewing gum, reduces the effects of articulation experience on word liking (Topolinski & Strack, 2009). Yet, many of these findings from embodied cognition research are difficult to replicate (e.g., Morey et al., 2021; Westerman et al., 2015). Moreover, previous research on the in-out effect has failed to find any moderating influence of oral motor interference on the effect (Lindau & Topolinski, 2018), questioning the role of motor simulations and, therefore, the concept of a generalized articulatory representation behind inward/outward stimulus materials. Thus, other accounts that do not require this assumption of simulations and generalized representations should also be considered.

Position-specific consonant preferences as an alternative explanation

A more recent account of the in-out effect does not require the concept of a generalized representation of inward/outward dynamics. In fact, it does not even require the concept of articulation dynamics: Maschmann et al. (2020) postulated that the in-out effect is not based on the preference for inward over outward dynamics but is an epiphenomenon due to the specific consonants appearing at different positions within inward/outward stimuli. For instance, in the word BODIKA, the [b] appears at the word beginning, whereas the [k] appears at the word ending. Maschmann et al. (2020) argue and present data that the position of a single consonant within a stimulus is sufficient to induce preferences consistent with an in-out effect pattern. For instance, they showed that stimuli starting with a labial consonant [b] are generally preferred to those starting with a dorsal consonant [k] (see Ingendahl, Vogel, & Wänke, 2022 for similar findings). There is evidence also for position-specific preferences at ending positions (e.g., _ _ _ K _ is liked less than _ _ _ B _; Maschmann et al., 2020), but preferences on ending positions seem to depend on the stimulus structure (Ingendahl & Vogel, 2022b; Körner & Rummer, 2021).

Even though the origin of such position-specific consonant preferences is still poorly understood (Ingendahl, Vogel, & Wänke, 2022), the core assumption of this consonant preference account is intriguing: The effect is not due to a preference of inward over outward articulation dynamics, but an epiphenomenon due to preferences for specific consonants appearing at specific positions. Thus, this account does not presume that inward/outward stimuli are represented as inward/outward to influence stimulus liking. Furthermore, this account does not even assume that single consonants are represented according to their place of articulation. A labial consonant [b] does not need to be represented as labial, and a dorsal consonant [k] does not need to be represented as dorsal to induce preferences. Thus, there is no need for a generalized representation underlying inward/outward stimuli.

Articulation Dynamics and Evaluative Conditioning

To conclude, the two accounts differ regarding the underlying representation of an inward/outward dynamic. The oral approach/avoidance account holds that consonantal places of articulation constitute a representation of an inward/outward dynamic. The consonant preference account does not require this assumption[1]. Thus, evidence for or against a generalized representation of words as inward/outward may help to appraise the two accounts.

To explore this issue, we borrowed assumptions from evaluative conditioning (EC). EC is the change in attitudes due to pairing a conditioned stimulus (CS) with a positive/negative unconditioned stimulus (US) (De Houwer et al., 2001). For example, let us assume that an individual encounters multiple inward words, such as BODIKA and PATUGE, and a negative stimulus accompanies each word. At the same time, the respective outward counterparts with a reversed consonant order (KODIBA, GATUPE) are accompanied by a positive stimulus. In the present example, EC would lead to a more negative evaluation of the inward words BODIKA and PATUGE and a more positive evaluation of the outward words KODIBA and GATUPE. The crucial question is, could EC also influence the evaluation of inward/outward words that were not paired with positive/negative US?

Indeed, EC does not only impact the single CS, but the effects generalize beyond individual stimuli (Glaser & Kuchenbrandt, 2017; Halbeisen et al., 2020; Högden et al., 2020;

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[1] There is also a third account on the in-out effect, namely that the effect is due to a higher fluency of inward over outward words (Bakhtiari et al., 2016; Ingendahl et al., 2021; Körner et al., 2019). However, this account has not found any support in recent research (Ingendahl et al., 2021; Ingendahl, Vogel, & Wänke, 2022) and is thus not discussed further in this paper.

Hütter et al., 2014; Hütter & Tigges, 2019; Jurchiș et al., 2020; Kocsor & Bereczkei, 2017; Luck et al., 2020; Vogel et al., 2021). Specifically, EC effects generalize to stimuli from the same category (Glaser & Kuchenbrandt, 2017; Vogel et al., 2021) and stimuli similar to the original CS (Gawronski & Quinn, 2013; Halbeisen et al., 2020; Högden et al., 2020). Applied to the present issue, if we were to condition a word, the EC effect should spread to other words containing the same consonant sequences as the conditioned words. For instance, conditioning BODIKA negatively should also reduce the liking of the similar word BADIKO.

Furthermore, EC generalization is not restricted to specific cues within the conditioned stimuli, but it has also been shown to influence more abstract representations – even those that individuals are not fully aware of (Jurchiș et al., 2020; Kocsor & Bereczkei, 2017; Vogel et al., 2021). In one notable study, Jurchiș and colleagues (2020) presented participants with letter strings from two complex artificial grammars. Whereas strings from one grammar were conditioned positively, strings from the other grammar were conditioned negatively. Jurchiș and colleagues (2020) found that the EC effect generalized to new strings from these abstract grammars even if participants were unaware of the grammar structure. In our example, a similar abstract structure of words is the articulation dynamic. Thus, even words that do not share any visual similarity, but only the articulation dynamic with the conditioned words (e.g., MENURO, RENUMO) may be influenced by the conditioning procedure.

However, this depends on the theoretical accounts of the articulatory in-out effect and the underlying representation they presume. According to the oral approach/avoidance account, the EC procedure should change the liking of the underlying generalized representation of inward/outward stimuli: Every time an inward/outward stimulus is encountered, and an inward/outward dynamic is represented, there is also a positive/negative US. This conditioning effect should thus influence the valence of the representations “inward” and “outward” as well, thereby attenuating or reversing the in-out effect. Crucially, this attenuation/reversal should appear for all stimuli that follow an inward/outward dynamic, even if they do not have any other features in common with the conditioned words. Thus, conditioning BODIKA and KODIBA should influence the evaluation of MENURO and RENUMO as well.

The consonant preference account does not presume that people have a generalized representation of inward/outward dynamics. Thus, the conditioning effect cannot generalize to other words that only share the same articulation dynamic with the conditioned words. Furthermore, it does not even presume that consonants are represented as belonging to specific places of articulation. Thus, people would not even be conditioned on “starting labial/dorsal” or “ending labial/dorsal” as mental concepts. Therefore, conditioning BODIKA and KODIBA should not influence the evaluation of MENURO and RENUMO, for which a regular in-out effect should occur irrespective of the conditioning.

Hypotheses

The different predictions provide a unique chance to further test the underlying mechanisms of the in-out effect. To do this, we conducted three experiments in which we conditioned inward and outward words. In one experimental group, inward words were conditioned negatively and outward words positively. In a control group, outward words were conditioned positively and inward words negatively. Afterward, inward and outward words were evaluated. Crucially, the conditioned inward/outward words were constructed only from a subset of consonants. This made it possible to let participants evaluate inward/outward words that

a) Were conditioned (same words), or
b) Were generated from the same consonant sequences as the conditioned words (same consonants but different vowels), or
c) Were generated from consonants that had not been used in the conditioning procedure.

For the conditioned words (type a), there should be an EC effect which should manifest in the following way in this design (see Figure 1):

H1: EC moderates the preference for inward over outward words for *conditioned* words, such that the preference for inward over outward words is attenuated or reversed when inward words were conditioned negatively and outward words positively.

Next, one would expect that the EC effect generalizes to other inward/outward words from the same consonant sequences (type b). This is not of theoretical relevance but a necessary precondition to see whether EC effects generalize at all in our paradigm. For these words, we thus expect:

H2: EC moderates the preference for inward over outward words for words constructed from the *same consonant sequences* as words in the conditioning phase, such that the preference for inward over outward words is attenuated or reversed when inward words were conditioned negatively and outward words positively.

The words generated from new (unconditioned) consonants provide a straightforward test for the representation underlying inward/outward dynamics. Thus, expectations differ here: Based on the oral approach/avoidance account, the EC manipulation should change the valence associated with the representation of an inward/outward dynamic: This should impact the in-out effect also for words that share no other similarity with the conditioned words other than the articulation dynamic. However, according to the consonant preference account, there is no generalized representation of inward/outward words, and thus the in-out effect should not be modulated for these words. Hence, the critical hypothesis for this research is:

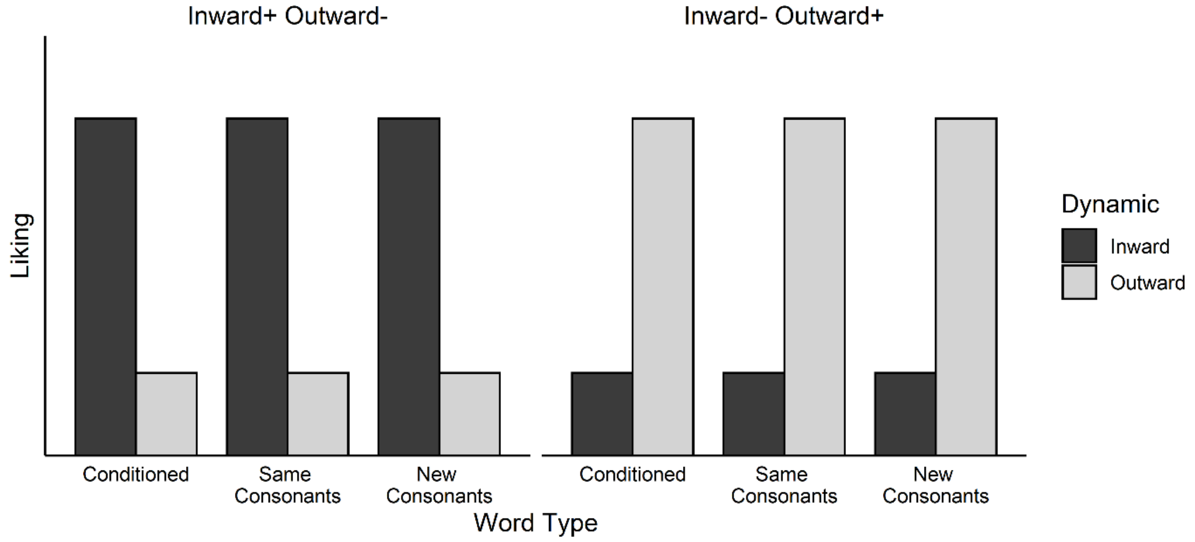
H3: EC moderates the preference for inward over outward words that only share the articulation dynamic of the CS (*new-consonants words*), such that the preference for inward over outward words is attenuated or reversed when inward words were conditioned negatively and outward words positively.

The different predictions based on the two accounts are illustrated in Figure 1.

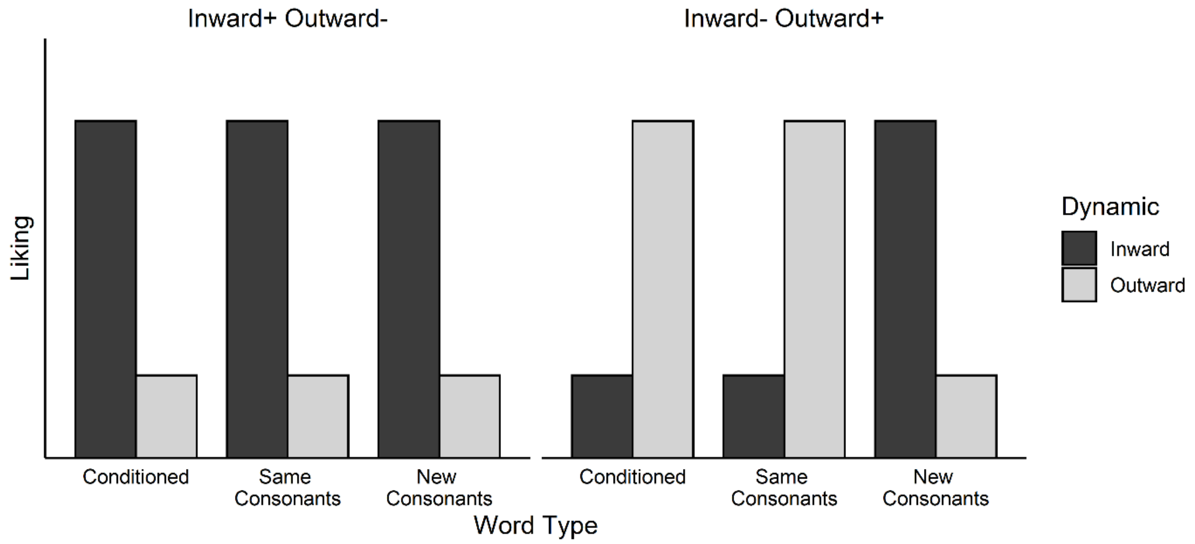
Figure 1

Predicted Pattern based on a Generalized Representation of Articulation Dynamics (a) and Without a Generalized Representation (b)

a)



b)



Note. The specific pattern within each word type (e.g., symmetric reversal, weak reversal, attenuation of the in-out effect) depends on the strength of the in-out effect and evaluative conditioning. As long as the difference between inward and outward words within each word type depends on the conditioning procedure, the respective hypothesis H1-3 is supported.

We tested these hypotheses with three experiments that followed a very similar procedure and only differed in the specific CS and US materials. Experiments 2 and 3 were pre-registered on the Open Science Framework (https://osf.io/6vzh2/?view_only=e24456fc0e4b4309bdaeeebf142cb7ac and https://osf.io/5cmzy/?view_only=9ad0c603e0f146559a2aa904efa50ca6). All data, materials, and analysis scripts can be accessed via https://osf.io/8qc5d/?view_only=efe95d84e63345ba990f2f86a75171f0.

Experiment 1

Methods

Design

This experiment followed a 2(conditioning: inward+outward- vs. inward-outward+) x 3(word type: conditioned vs. same consonants vs. new consonants) x 2(dynamic: inward vs. outward) mixed design, with conditioning manipulated between and the other two factors manipulated within participants.

Procedure

This experiment was conducted in the lab and implemented in the software OpenSesame (Mathôt et al., 2012). Participants were randomly assigned to the two between-participant conditions. After providing informed consent, participants were told that they would see some words presented together with pictures. They were instructed to speak each word silently for themselves. In the following conditioning phase, 18 inward and 18 outward words were presented together with positive/negative US. For individuals in the inward+outward- condition, all inward words were paired with positive US and all outward words were paired with negative US (vice versa for the inward-outward+ condition). For each trial, a random positive (or negative) US was drawn. After a fixation dot of 500ms, both word and US were presented simultaneously for 3500ms. We counterbalanced between participants whether a word or a US was presented on the right/left side of the screen. Each word was paired five times, leading to overall 36 x 5 = 180 trials of conditioning, presented in random order.

After the conditioning phase, participants evaluated 36 inward and 36 outward words in random order. These words consisted of 12 inward and 12 outward words of each level of the factor word type: words from the conditioning phase, words built from the same consonants as in the conditioning phase, and words built from entirely new consonants. Each word was presented on a single slide with the question “How much do you like this word?” and a 9-point scale (with the labels 1 = *not at all* to 9 = *very much*). Afterward, participants’ sociodemographic data were assessed, participants were probed for guessing the purpose of the study and whether they had identified any system in the word materials. Finally, they were debriefed, thanked, and dismissed. In line with our university's ethics committee guidelines, the experiments reported in this paper did not require specific approval.

Materials

The words were generated randomly and ad-hoc for each participant to avoid systematic confounds, with a technique similar to Ingendahl et al. (2021). Because of the German sample, we used B, P, M, W, F as labial consonant letters; T, L, N, S, D, as coronal consonant letters; and G, K, R as dorsal consonant letters. Each of the three consonant lists was randomized for each participant, thus leading to different word material for each participant. One exemplary word set is provided in Table 1.

Two random labial consonants (e.g., B, P), two random coronal consonants (e.g., T, L), and one random dorsal consonant (e.g., G) were set aside for later use in the new-consonant words. The remaining eight consonants (e.g., M, W, F, N, S, D, K, R) were used to create the words for the conditioning phase. From these consonants, all 3 x 3 x 2 = 18 possible inward sequences were built (e.g., MNK, MNR, MSK, MSR, …, FDR). After each consonant, a random vowel was inserted, leading to 18 inward words (e.g., MENAKI, MUNARI, …). For each inward word, the respective outward counterpart was generated by switching the first and the last consonant (e.g., KENAMI, RUNAMI, …). These 18 inward and 18 outward words were used in the conditioning phase.

For the rating phase, we selected 12 of the 18 inward words (and their outward counterpart) from the conditioning phase (same words). The 12 same-consonant words were generated by using the same words, but switching the order of the first and the last *vowel*. Thus, if MENAKI and KENAMI were used as conditioned words, MINAKE and KINAME were used as same-consonant words.

For the new-consonant words, two labial (e.g., B, P), two coronal (e.g., T, L), and one dorsal (e.g., G) consonants were left that had not been used in the conditioning phase, resulting in four different inward consonant sequences. Each of them was filled with vowel 1, 2, 3, or 2, 3, 4, or 3, 4, 5 from the randomized vowel list, e.g., BATOGU, BOTUGI, BUTIGE. The outward counterpart was generated by reversing the consonant order. Overall, this procedure led to another 12 inward and 12 outward words for each word type (see Table 1).

As US, we selected 50 pictures with positive and 50 pictures with negative valence from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) that had been used in previous EC research (Vogel et al., 2021). In the IAPS manual, the positive and negative pictures differ in their valence, $t(98) = 56.88$, $p < .001$, but not in arousal, $t(98) = -0.92$, $p = .360$. A list of the pictures can be found in the Online supplement.

Table 1

Sample Stimuli for a Single Participant Resulting from the Material Generation in Experiment 1

Phase	Dynamic of Conditioned Words: Inward	Dynamic of Conditioned Words: Outward
Conditioning	MENAKI, MUNARI, MISAKO, MUSARO, MADIKU, MEDIRO, WENUKA, WINORA, WASEKI, WOSARU, WADIKU, WODARI, FANIKO, FONURE, FASIKU, FOSIRA, FEDAKI, FODERU	KENAMI, RUNAMI, KISAMO, RUSAMO, KADIMU, REDIMO, KENUWA, RINOWA, KASEWI, ROSAWU, KADIWU, RODAWI, KANIFO, RONUFE, KASIFU, ROSIFA, KEDAFI, RODEFU

Phase	Dynamic of Rated Words					
	Inward			Outward		
	Conditioned	Same Consonants	New Consonants	Conditioned	Same Consonants	New Consonants
Rating	MENAKI	MINAKE	BATOGU	KENAMI	KINAME	GATOBU
	MUNARI	MINARU	BOTUGI	RUNAMI	RINAMU	GOTUBI
	MISAKO	MOSAKI	BUTIGE	KISAMO	KOSAMI	GUTIBE
	MUSARO	MOSARU	BALIGO	RUSAMO	ROSAMU	GALIBO
	MADIKU	MUDIKA	BILOGE	KADUMI	KUDIMA	GILOBE
	…	…	…	…	…	…
	WODARI	WIDARO	POLAGI	RODAWI	RIDAWO	GOLAPI

Note. Words were generated randomly and ad-hoc for each participant. Thus, the word material was different for each participant.

Power Analysis and Sample

We calculated a-priori power analyses with G*Power 3 (Faul et al., 2007). As a conservative approximation for Experiment 1, we sought to detect a small to medium (f = .15) interaction of Conditioning x Dynamic within each word type. As further input criteria, we used α = .05, 1-β = .8, correlation among repeated measures = .5, leading to a necessary sample size of 90 participants. This was also the necessary sample size to replicate a small to medium (f = .15) in-out effect in case no effect of EC could be found for a word type.

90 (74% female, 26% male, M_{Age} 23.44, SD_{Age} = 7.72) participants were recruited on our University campus and offered course credits, coffee, and sweets. 92% of all participants

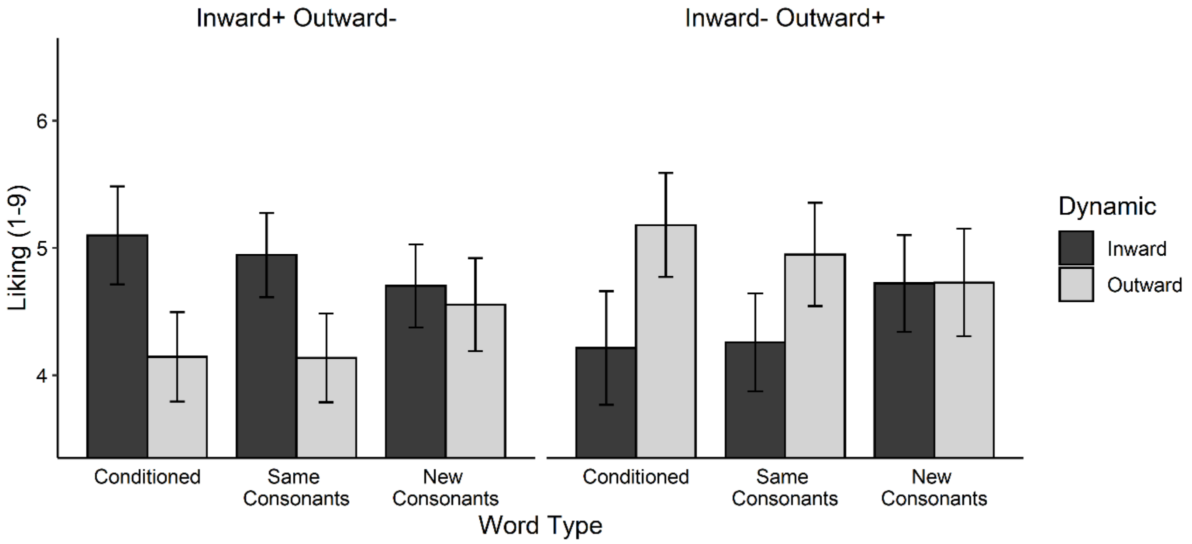
were students, and 48% studied psychology. Almost every participant (98%) was a native German speaker, and the other 2% stated that their German was very good. When asked about a system behind the words, three participants recognized the articulatory in-out effect as the systems underlying the words (the effect had just been taught in a course). Therefore, these participants were excluded from all further analyses. Consequently, the sample size was reduced to 87 participants.

Results

We conducted a mixed ANOVA on the ratings with the afex package in R (Singmann et al., 2020). Due to violations of sphericity, we report Greenhouse-Geisser corrected values for the word type main effect and the Word Type x Dynamic interaction. The results of Experiment 1 are visualized in Figure 2. Full descriptive statistics for all experiments are provided in the Online Supplement.

Figure 2

Mean Word Evaluation in Experiment 1 (N = 87)



Note. Error bars represent 95% confidence intervals.

We observed a Conditioning x Dynamic interaction, $F(1, 85) = 32.74$, $p < .001$, $\eta^2_G = .054$, which indicated that the preference for inward over outward words depended on the conditioning procedure. However, this two-way interaction was qualified by a Conditioning x Word Type x Dynamic interaction $F(1.5, 127.33) = 17.48$, $p < .001$, $\eta^2_G = .022$, indicating that the two-way interaction depended on the specific test word type. All other terms were not significant, all Fs < 0.30, all ps > .633. To further investigate the three-way interaction, we split the three-factorial ANOVA into three separate ANOVAs, one for each word type.

Consistent with H1, there was a Conditioning x Dynamic interaction for the conditioned words, $F(1, 85) = 35.34$, $p < .001$, $\eta^2_G = .119$. As visualized in Figure 2, inward words were preferred to outward words if inward words were conditioned positively, $t(85) = 4.53$, $p < .001$, which reversed if inward words were conditioned negatively, $t(85) = -3.95$, $p < .001$.

Consistent with H2, a Conditioning x Dynamic interaction emerged for the same-consonant words, $F(1, 85) = 23.79$, $p < .001$, $\eta^2_G = .088$: Inward words were preferred to outward words if inward words were conditioned positively, $t(85) = 4.03$, $p < .001$, which reversed if inward words were conditioned negatively, $t(85) = -2.96$, $p < .001$.

For the new-consonant words however, the Conditioning x Dynamic interaction was not significant, $F(1, 85) = 0.82$, $p = .367$, $\eta^2_G = .001$. Overall, this suggests no conditioning effect for this word type, which is inconsistent with H3. All main effects from the separate ANOVAs were insignificant, all Fs < 0.68, all ps > .410.

Discussion

Experiment 1 provides a first test for our hypotheses. As expected in H1 and H2, EC modulated and even reversed the in-out effect for conditioned words and words with the same consonants. Contrary to H3, EC did not modulate the in-out effect for words constructed from new consonants. However, even in the absence of any modulation, there should be an in-out effect, which could not be observed here. There may be various reasons for this: On the one hand, this could be merely an issue of statistical power due to the low number of inward/outward new-consonant words (12). On the other hand, this could be caused by these words' homogeneity due to their limited set of consonants.

We conducted two further experiments with the following improvements to tackle this: First, we altered the stimulus distribution and the material generation to have more and more diverse new-consonant words. Second, we used words that consisted only of one vowel (e.g., BADAKA, KADABA) instead of three vowels to make learning the association of articulation dynamics and valence easier. Using the same vowel in a word does not diminish the in-out effect (Ingendahl et al., 2021; Körner et al., 2019). Third, we pre-registered both experiments on the OSF. As both experiments followed a very similar procedure, they are reported together.

Experiments 2 & 3

Methods

Design

Both experiments followed the same design as Experiment 1.

Procedure

Due to the Covid-19 outbreak in 2020, both experiments were conducted online with the web version of OpenSesame (Mathôt et al., 2012). The experiments could only be completed on computers, not on tablets or mobile phones. They had the same structure and instructions as in Experiment 1, with the following modifications: First, the conditioning phase consisted of 32 instead of 36 words, due to a change in the material generation. As an attention check for the long conditioning phase, two trials were included where participants had to press a button within 30 seconds. If they did not react in time, they could not proceed further with the experiment. Also, the conditioning procedure was paused once the participant switched a tab or a window on their computers. As mentioned above, we changed the stimulus distribution in the rating phase: Participants evaluated 16 instead of 24 conditioned words and 16 instead of 24 same-consonant words, but 54 instead of 24 new-consonant words. To realize this, the algorithm to generate these words was modified (see next section). Finally, sociodemographics were not collected in OpenSesame, but in a separate questionnaire on Sosci Survey (Leiner, 2019).

Materials

Again, the words were generated randomly and ad-hoc for each participant, with the same consonants as in Experiment 1. However, the specific word construction algorithm differed from Experiment 1 to account for the necessary changes. One exemplary word set is provided in Table 2.

To increase the number of new-consonant words, one additional labial and one additional coronal consonant letter were saved for the new-consonant words. Thus, three random labial consonant letters (e.g., B, P, M), three random coronal consonant letters (e.g., T, L, N), and one random dorsal consonant letter (e.g., G) were set aside first for later use in the new-consonant words. The remaining six consonant letters (e.g., W, F, S, D, R, K) were used to create the words for the conditioning phase. From these letters, all 2 x 2 x 2 = 8 possible inward sequences were built (e.g., WSR, WSK, WDR, …, FDK). For each of these sequences, two words were generated by inserting the same random vowel after each consonant letter (e.g., WESERE, WASARA). Thus, there were overall 16 inward words, for which the outward counterparts were again built by reversing the consonant order.

In the rating phase, one word per inward sequence was chosen to be evaluated, together with their respective outward counterpart. Thus, there were eight inward and eight outward words for this word type. The same-consonant words were again generated by using the same consonant sequence but a different *vowel*. Thus, if WESERE or WASARA were conditioned, the word WUSURU could be used as a same-consonant word. Again, this resulted in eight inward and eight outward words for this word type.

For the new-consonant words, there were three labial (e.g., B, P, M), three coronal (e.g., T, L, N), and one dorsal (e.g., G) consonants left that had not been used in the conditioning phase, resulting in 3 x 3 x 1 = 9 different inward consonant sequences. Each of them was filled three times with a random vowel (e.g., BATAGA, BOTOGO, BUTUGU). The outward counterpart was again generated by reversing the consonant order. This led to 27 inward and 27 outward words for this word type.

As the IAPS cannot be used in online studies, we selected 50 positive and 50 negative pictures from the OASIS database as US (Kurdi et al., 2017). Positive and negative pictures differed in their valence, $t(98) = 138.27$, $p < .001$, but not in arousal, $t(98) = 0.13$, $p = .898$. A list of the pictures can be found on the OSF.

Table 2

Sample Stimuli for a Single Participant Resulting from the Material Generation in Experiments 2 & 3

	Dynamic of Conditioned Words					
Phase	Inward			Outward		
Conditioning	WESERE, WASARA, WUSUKU, WASAKA, WIDIRI, WODORO, WEDEKE, WUDUKU, FESERE, FUSURU, FASAKA, FESEKE, FIDIRI, FUDURU, FEDEKE, FODOKO			RESEWE, RASAWA, KUSUWU, KASAWA, RIDIWI, RODOWO, KEDEWE, KUDUWU, RESEFE, RUSUFU, KASAFA, KESEFE, RIDIFI, RUDUFU, KEDEFE, KODOFO		
	Dynamic of Rated Words					
	Inward			Outward		
	Identical	Same Consonants	New Consonants	Identical	Same Consonants	New Consonants
Rating	WESERE	WISIRI	BATAGA	RESEWE	RISIWI	GATABA
	WUSUKU	WESEKE	BOTOGO	KUSUWU	KESEWE	GOTOBO
	WIDIRI	WADARA	BUTUGU	RIDIWI	RADAWA	GUTUBU
	WEDEKE	WODOKO	BOLOGO	KEDEWE	KODOWO	GOLOBO
	FESERE	FASARA	BILIGI	RESEFE	RASAFA	GILIBI
	…	…	…	…	…	…
	FEDEKE	FIDIKI	MONOGO	KEDEFE	KIDIFI	GONOMO

Note. Words were generated randomly and ad-hoc for each participant. Thus, the word material was different for each participant.

Power Analysis and Sample

Experiment 2. We used the same power analysis as in Experiment 1 but added a buffer of 10 participants if some had to be excluded. Following the preregistration protocol, we kept the study online for a full week after N = 100 had been reached. We collected experimental data from N = 114 participants who were recruited via social media, mailing lists, and personal contacts. Students from our university were offered course credits as an incentive; additionally, 1€ was donated to UNICEF for each participant. Due to a technical malfunction of some web browsers, 12 participants were not forwarded to the sociodemographics questionnaire after the experiment. For the rest of our sample (81%

female, 19% male, M_{Age} = 26.96, SD_{Age} = 12.27) 79% were students and 47% studied psychology. Almost all participants (95%) were German native speakers, and the other 5% stated that their German was very good. None of the participants recognized the articulatory in-out effect as the system underlying the words. However, we excluded one participant for redundant answering (giving the same response for all words) and one additional participant requesting their data to be removed, leading to a final sample size of N = 112 for the main analysis.

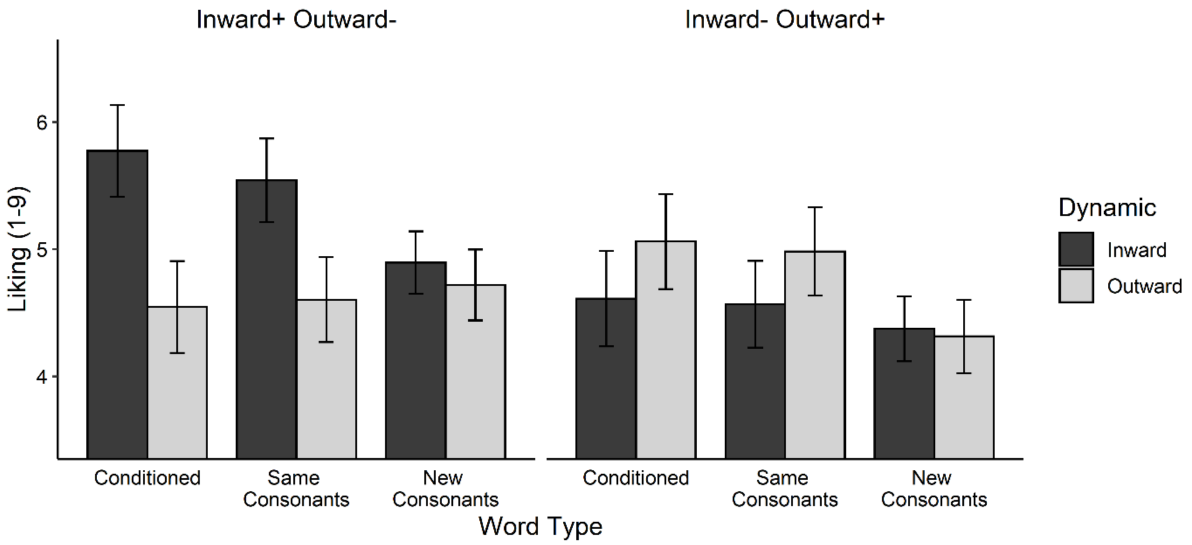
Experiment 3. Based on the effect sizes found in Experiment 2, we conducted a more conservative power analysis, assuming only a small effect (f = .1), leading to a required sample size of N = 200. In case participants needed to be excluded, we oversampled by 10%, leading to a final sample of N = 221 participants. Native German speakers were recruited via Prolific Academic to participate in a 15-20 minutes study for a payout of £2.10. Three participants did not provide sociodemographic data. For the rest of our sample (58% female, 39% male, 2% diverse, M_{Age} = 28.65, SD_{Age} = 10.5) 43% were students. None of the participants recognized the articulatory in-out effect as the system underlying the words.

Main pre-registered results

We followed the same analysis strategy as in Experiment 1. The results of Experiments 2 and 3 are visualized in Figures 3 and 4. Again, full descriptive statistics are provided in the OSF directory.

Figure 3

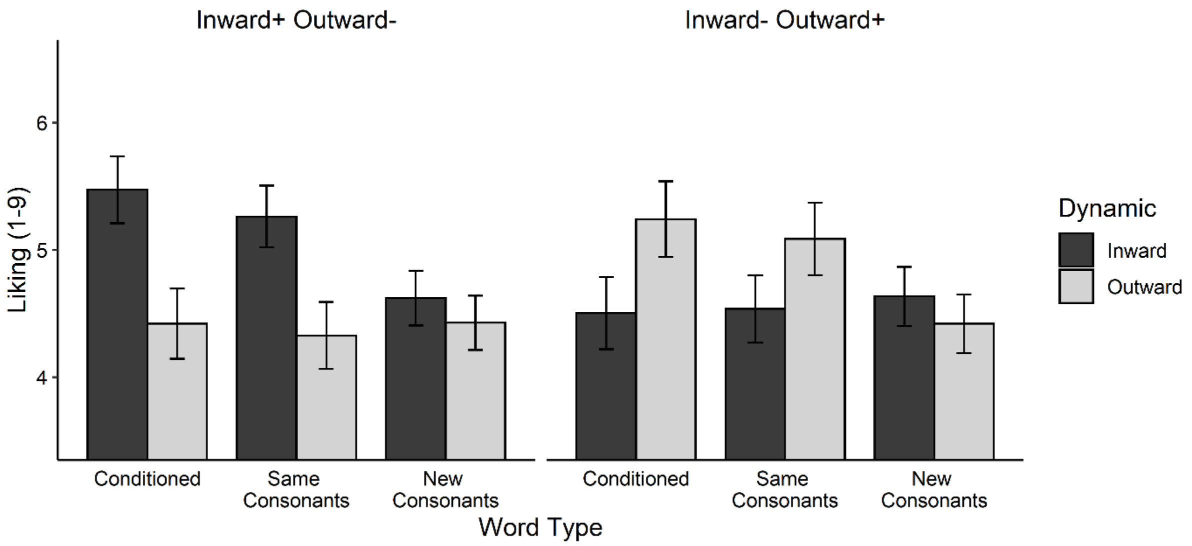
Mean Word Evaluation in Experiment 2 (N = 112)



Note. Error bars represent 95% confidence intervals.

Figure 4

Mean Word Evaluation in Experiment 3 (N = 221)



Note. Error bars represent 95% confidence intervals.

Experiment 2

Again, we observed a Conditioning x Dynamic interaction, $F(1, 110) = 28.38$, $p < .001$, $\eta^2_G = .044$, and a Conditioning x Word Type x Dynamic interaction $F(1.49, 163.87) = 20.84$, $p < .001$, $\eta^2_G = .018$. Unexpectedly, word evaluation was also generally more positive in the inward+outward- condition, than in the inward-outward+ condition, $F(1, 110) = 5.20$, $p = .024$, $\eta^2_G = .021$. Also, conditioned words and same-consonant words were evaluated overall more positively than new-consonant words, $F(1.67, 183.82) = 9.47$, $p < .001$, $\eta^2_G = .022$. Notably, there was also a general preference for inward compared to outward words, $F(1, 110) = 6.79$, $p = .010$, $\eta^2_G = .011$. All other terms were not significant, all *F*s < 2.27, all *p*s > .121. As in Experiment 1, we next split the three factorial ANOVA into three separate ANOVAs.

Consistent with H1, there was a Conditioning x Dynamic interaction for the conditioned words, $F(1, 110) = 32.41$, $p < .001$, $\eta^2_G = .085$. Inward words were preferred to outward words if inward words were conditioned positively, $t(110) = 6.00$, $p < .001$, which reversed if inward words were conditioned negatively, $t(110) = -2.12$, $p = .036$. However, the reversal was not as strong, and overall inward words were liked more than outward words, $F(1, 110) = 7.00$, $p = .009$, $\eta^2_G = .020$.

Consistent with H2, a Conditioning x Dynamic interaction emerged for the same-consonant words, $F(1, 110) = 22.83$, $p < .001$, $\eta^2_G = .067$: Inward words were preferred to outward words if inward words were conditioned positively, $t(110) = 4.77$, $p < .001$, which reversed if inward words were conditioned negatively, $t(110) = -2.04$, $p = .044$. As for the conditioned words, this reversal was slightly weaker and the main effect of dynamic marginally significant, $F(1, 110) = 3.42$, $p = .067$, $\eta^2_G = .011$.

For the new-consonant words the Conditioning x Dynamic interaction was not significant, $F(1, 110) = 0.94$, $p = .334$, $\eta^2_G < .001$. However, there was a marginally significant preference for inward compared to outward words, $F(1, 110) = 3.85$, $p = .052$, η^2_G

= .003. Additionally, there was a significant main effect of Conditioning, $F(1, 110) = 6.49$, $p = .012$, $\eta^2_G = .051$, with more positive word evaluation in the inward+outward- condition. Overall, this suggests that there is no conditioning effect for this word type, again providing no evidence for H3. All other effects from the separate ANOVAs were not significant, all F's < 2.32, ps $> .131$.

Experiment 3

Experiment 3 also revealed a significant Conditioning x Dynamic interaction, $F(1, 219) = 57.18$, $p < .001$, $\eta^2_G = .038$, and a Conditioning x Word Type x Dynamic interaction $F(1.55, 338.59) = 44.28$, $p < .001$, $\eta^2_G = .021$. Unexpectedly, and as in Experiment 2, conditioned words and same-consonant words were evaluated overall more positively than new-consonant words, $F(1.39, 305.40) = 12.17$, $p < .001$, $\eta^2_G = .014$. Again, there was also a general preference for inward compared to outward words, $F(1, 219) = 6.65$, $p = .011$, $\eta^2_G = .005$. All other terms were not significant, all Fs < 0.18, all ps $> .751$.

Consistent with H1, there was a Conditioning x Dynamic interaction for the conditioned words, $F(1, 219) = 61.36$, $p < .001$, $\eta^2_G = .083$. Inward words were preferred to outward words if inward words were conditioned positively, $t(219) = 6.78$, $p < .001$, which reversed if inward words were conditioned negatively, $t(219) = -4.40$, $p < .001$.

Consistent with H2, a Conditioning x Dynamic interaction also emerged for the same-consonant words, $F(1, 219) = 47.83$, $p < .001$, $\eta^2_G = .066$: Inward words were preferred to outward words if inward words were conditioned positively, $t(219) = 6.41$, $p < .001$, which reversed if inward words were conditioned negatively, $t(219) = -3.49$, $p < .001$. As in Experiment 2, this reversal was slightly weaker, resulting in a marginally significant effect of dynamic, $F(1, 219) = 3.22$, $p = .074$, $\eta^2_G = .005$.

For the new-consonant words, the Conditioning x Dynamic interaction was again not significant, $F(1, 219) = 0.08$, $p = .780$, $\eta^2_G < .001$. However, there was a significant preference for inward compared to outward words, $F(1, 219) = 28.43$, $p < .001$, $\eta^2_G = .007$.

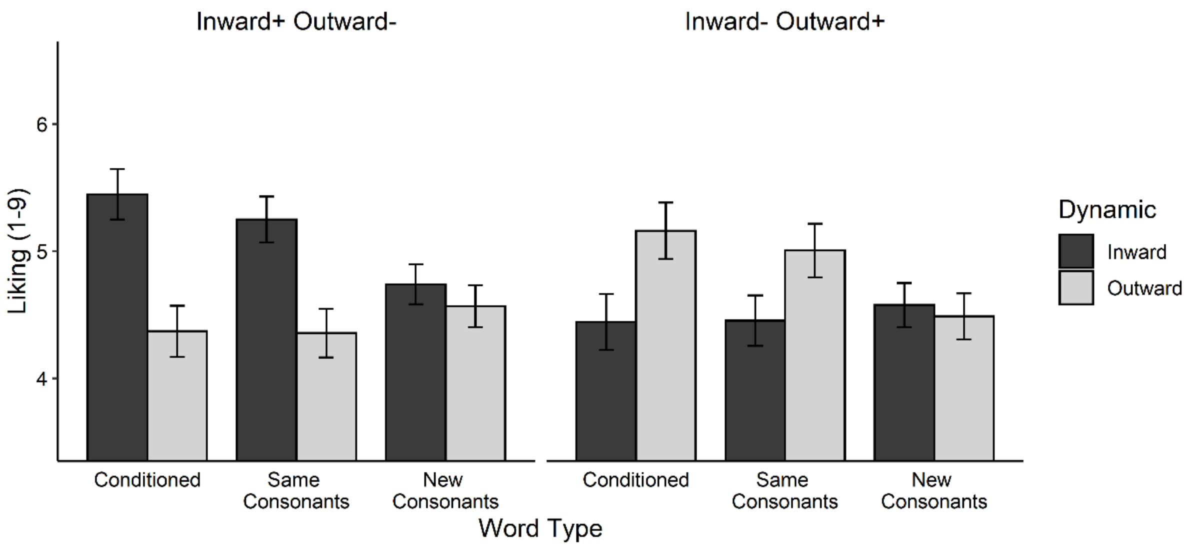
Again, this suggests no conditioning effect for this word type, providing no evidence for H3. All other effects from the separate ANOVAs were insignificant, all *F*'s < 1.90, *p*s > .170.

Further Analyses

To further examine whether the absence of the interaction for H3 within the new-consonant words was merely an issue of power, we also conducted a Bayesian ANOVA in the R package BayesFactor with default settings (Morey & Rouder, 2018) which revealed BF_{10} = 0.33 for Experiment 1, BF_{10} = 0.28 for Experiment 2, and BF_{10} = 0.15 for Experiment 3. Additionally, as all three experiments followed a very similar procedure, we also conducted an integrative data analysis over all data sets (Curran & Hussong, 2009). We included the additional factor experiment with all interaction terms for that purpose. Except for a small and irrelevant Experiment x Word Type interaction, $F(2.78, 576.18) = 2.71$, $p = .049$, $\eta^2_G = .004$, none of the terms with this factor reached significance (all *p*s > .151). In this analysis, the critical interaction of Conditioning x Dynamic in the new-consonant words was again insignificant, $F(1, 414) = 1.52$, $p = .219$, $\eta^2_G < .001$, $BF_{10} = 0.15$, but only the main effect of dynamic was significant with more positive evaluation of inward (vs. outward) words, $F(1, 414) = 15.13$, $p < .001$, $\eta^2_G = .003$, $BF_{10} = 11315.96$. The rest of these results were very similar to Experiment 3 and are thus not reported here (see Figure 5 for the pattern and the OSF directory for detailed results).

Figure 5

Mean Word Evaluation in Integrative Data Analysis (N = 420)



Note. Error bars represent 95% confidence intervals.

General Discussion

The articulatory in-out effect describes the preference for linguistic stimuli with inward- over outward articulation dynamics and has proven to be empirically robust but not well understood (Ingendahl, Vogel, & Topolinski, 2022; Topolinski et al., 2014). To further our understanding of this phenomenon, we examined whether people have a generalized representation of inward/outward articulation dynamics. To do so, we employed an evaluative conditioning (EC) paradigm to investigate whether EC effects generalized to words with different consonants but identical inward/outward dynamics. In all three experiments, a similar pattern emerged: EC modulated the preference for inward over outward words if the words had been used in the conditioning phase or were constructed from the same consonant sequences of the conditioning phase. However, inward/outward words constructed from new, unconditioned consonants were not influenced by EC. For these words, the classic in-out effect emerged instead (in Experiments 2 & 3 and an integrative data analysis).

We believe that these findings can be interpreted in two different ways: Either the in-out effect does not require a generalized representation of inward/outward dynamics, or our EC procedure could not alter the association of inward/outward dynamics with positive/negative valence. In the following, we will discuss both possibilities and their implications for in-out effect research.

The In-Out Effect does not require a Generalized Representation of Inward/Outward Dynamics

The theoretical accounts of the in-out effect differ in the assumed underlying representation of inward/outward stimuli. The oral approach/avoidance account presumes that a generalized representation exists. The consonants in inward/outward stimuli are assumed to constitute a sequence of different articulation places. This sequence is motorically simulated, and this representation of an inward/outward dynamic activates associated positive/negative affect (Topolinski et al., 2014). The more recent consonant preference account assumes that position-specific preferences for single consonants drive the effect, and therefore no generalized representation of an inward/outward dynamic is necessary for the in-out effect (Maschmann et al., 2020).

Our findings support the latter account: The EC effect was exclusive to the conditioned consonant sequences, but it did not spread to inward/outward words that shared only the articulation dynamic with the conditioned words. This implies that no generalized representation of inward/outward dynamics exists, speaking for position-specific preferences for single consonants underlying the in-out effect. Thus, our results align with previous findings on the in-out effect and the oral approach/avoidance account in particular: Suppressing oral motor simulations (e.g., via concurrent whispering) does not attenuate the in-out effect (Lindau & Topolinski, 2018), suggesting that the effect indeed does not require such simulations. Furthermore, modulating food-related states of the individual (e.g., via hunger or disgust induction) does not influence the in-out effect (Ingendahl & Vogel, 2022a;

Maschmann et al., 2020), questioning whether the effect is based on food-related associations with articulation dynamics.

Furthermore, our findings also offer important insights on the role of the in-out effect in natural language. Articulation dynamics lose influence for a specific inward/outward word if it is associated with a positive/negative concept. Once an inward/outward word becomes associated with a specific positive/negative concept in our environment (i.e., the inward name MONIKA is associated with a specific person one likes/dislikes), the liking towards this specific inward/outward word is influenced rather by the positive/negative concept than the articulation dynamic of the word. Moreover, such pairings with positive/negative concepts even generalize to similar words (e.g., words with the same consonant sequences such as MENIKA), but not to other inward/outward words with the same articulation dynamic but different consonants. Also, our findings speak against previous ideas that inward dynamics might simply occur more often in positive words and outward dynamics in negative words in natural language, leading to a learned association of articulation dynamics with valence (Topolinski & Bakhtiari, 2016). If that were indeed the case, one should expect that valence can generalize from some inward/outward stimuli to others, irrespective of the specific consonants. However, our findings show that this is not the case.

The Boundary Conditions of EC Generalization

Another reasonable interpretation of our results is that articulation dynamics do have a generalized representation, but the EC procedure simply did not influence the association of this generalized representation with positive/negative valence. Instead, it only changed the association of specific consonant sequences with positive/valence, with a remaining additive impact of the articulation dynamic that always favors inward over outward words. Consistent with this argument, we observed an overall main effect of articulation dynamics even for the conditioned or the same-consonant words in some of the experiments.

This interpretation would imply that the association between articulation dynamics and valence even withstands a long conditioning procedure of 180 trials and 15 minutes duration. This robustness can even be quantified based on our findings. A posthoc sensitivity analysis in GPower (Faul et al., 2007) revealed that the integrative data analysis was sufficiently powered (.80) to capture a minimal conditioning effect for the new consonant words ($f < .07$), which is less than a fifth of the conditioning effect for the other two word types. Thus, the association of articulation dynamics with valence must be very robust. Otherwise, at least some attenuation should have been visible in the data.

However, the failure to change this association may not only be due to the robustness of the association. Instead, it could even suggest important boundary conditions of generalization effects in EC. Previous findings already show that EC generalization is – like standard EC effects –stronger if individuals are aware of the contingency of CS and US, or of single CS features and US (Glaser & Kuchenbrandt, 2017; Sweldens et al., 2014). Our participants were unaware of the articulation dynamics; at least, they did not report articulation dynamics as a rule behind the words. Thus, participants were also unlikely to consciously process the pairing of articulation dynamics with positive/negative US, making it less likely to detect EC generalization for the new-consonant words. As some studies show that EC generalization is possible without awareness of the underlying structure (Jurchiș et al., 2020), articulation dynamics might prove a fruitful test case for future studies on the boundary conditions of EC generalization.

Conclusion

In three experiments, we do not find any evidence for a generalized representation of inward/outward dynamics. This is an important insight on the processes underlying the in-out effect and further speaks against an effect of simulated articulation dynamics. Overall, these findings attest to the robust influence of both articulation dynamics and EC on evaluative judgments.

Data availability statement

Experiments 2 and 3 were pre-registered on the OSF (https://osf.io/6sfbr/?view_only=dff67e9fe8f942f19130b366e9315a06 and https://osf.io/5cmzy/?view_only=9ad0c603e0f146559a2aa904efa50ca6). All materials, data, and analyses in this manuscript are provided on the OSF (https://osf.io/8qc5d/?view_only=efe95d84e63345ba990f2f86a75171f0).

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TITLE: The articulatory in-out effect – driven by consonant preferences?

Abstract

The articulatory in-out effect describes the preference for stimuli with an inward-wandering consonant order (e.g., BODIKA) as opposed to an outward-wandering consonant order (e.g., KODIBA). Originally, the in-out effect has been explained in terms of articulation trajectories, with inward trajectories being preferred over outward trajectories. However, recent research by Maschmann et al. (2020) raised doubts on this explanation of articulation trajectory preferences, and offered a parsimonious alternative explanation for the in-out effect based on consonant preferences instead. As we show in the present paper, stimulus materials in Maschmann et al. (2020) diverged from materials used in previous research, and might have prevented the experience of articulation trajectories. Here, we present a conceptual replication of Maschmann et al. (2020), using stimulus materials more likely to elicit articulation trajectory preferences. In a preregistered, high-powered experiment (N = 349), we find strong support for the original idea of trajectory preferences, but no evidence for the consonant preference account. Our research shows that preferences for articulation trajectories are robust and cannot be explained by mere consonant preferences. We discuss further implications of these findings for future research on the processes involved in the empirical in-out effect.

Keywords: in-out effect, embodied cognition, language, word processing

Bodily states are deeply intertwined with psychological states. In the last decades, a vast amount of research has studied how bodily states shape our attitudes, affect, or motivation, a research area commonly referred to as embodied cognition (Krishna & Schwarz, 2014; Meteyard et al., 2012; Topolinski et al., 2014; Vogel & Wänke, 2016). One general rationale in embodied cognition research is that proprioceptive feedback influences attitudes (cf., Schwarz & Lee, 2018). Several hypotheses have been derived from this rationale and demonstrated experimentally, for example how a fast heartbeat can increase the attractiveness of erotic material (Valins, 1966) or smiling can increase the funniness of comics (Strack et al., 1988). More recently, a new branch of research on the *articulatory in-out effect* suggests that proprioceptive feedback might even be generated by something as mundane as word articulation. Yet, similar to other research areas of embodied cognition (e.g., Wagenmakers et al., 2016), findings and theories on this in-out effect are currently under critical re-investigation (Maschmann et al., 2020). Here, we build on this research to shed more light on the processes behind the in-out effect. Specifically, we contribute to a better understanding of proprioceptive feedback by providing a clear test for two explanations behind the in-out effect.

Articulation Trajectories and Word Preferences

A new connection between bodily and psychological states was put forward by Topolinski et al. (2014), who theorized about the shared motor-mouth activities of articulation and food consumption. Because food deglutition (e.g., eating) is inherently positive and food expectoration (e.g., spitting) is inherently negative, they assumed that the underlying motor trajectories should induce motivational states of approach or avoidance – even when using these trajectories for different purposes, such as articulating words. As an example, in the word BODIKA the B is first formed at the lips, then the D with the tip of the tongue, and last the K at the rear of the tongue. Therefore articulation follows an inward trajectory similar to food deglutition. In the word KODIBA, on the other hand, the consonants are ordered the opposite way; therefore articulation follows an outward trajectory similar to food expectoration. Due to the similarity of these inward/outward articulation trajectories with the motor patterns of food consumption, Topolinski et al. (2014) expected that words following an inward trajectory are liked more, on average, than words following an outward trajectory, meaning that BODIKA would be preferred to KODIBA. This empirical preference for stimuli with an inward-oriented articulation trajectory over words with an outward-oriented trajectory was denoted (articulatory) *in-out effect* in later research.

Since the seminal work of Topolinski et al. (2014), a lot of research has built on this theoretical idea that articulation trajectories influence liking for linguistic stimuli (cf. Topolinski, 2017). Most research has held on to the classic paradigm of Topolinski et al. (2014), namely letting participants evaluate pseudowords composed of consonants from different articulation spots (e.g., Bakhtiari et al., 2016; Garrido et al., 2019; Ingendahl et al., 2021; Körner et al., 2019): As an example from the German language, “B”, “M”, “P”, are labial consonants generated at the front, “T”, “L”, “D” alveolar consonants generated in the middle, and “G”, “K”, “R” velar/uvular consonants generated at the rear of the mouth. Whenever a word is composed of first a front, then a middle, and then a rear consonant (e.g., BETIGO, MELUKA, PADIRU) articulation follows an inward-directed articulation trajectory. However, pseudowords that start with a rear, followed by a middle, and then a front consonant (e.g., GETIBO, KELUMA, RADIPU) follow an outward-oriented articulation trajectory. Overall, research within this paradigm has shown that participants prefer inward words over outward words, independent of the specific vowels used within the words (Topolinski & Boecker, 2016a). Within this paradigm, the idea of articulation trajectory preferences has found almost universal support with words in diverse languages including English, German (Topolinski et al., 2014, 2015), Portuguese (Godinho & Garrido, 2016), Ukrainian, and Turkish (Godinho, Garrido, & Horchak, 2019). These word preferences were found in laboratory settings (Gerten & Topolinski, 2018; Lindau & Topolinski, 2018a), but also in more applied settings: As an example, eBay sellers with an inward name are seen as more trustworthy (Silva & Topolinski, 2018), and food labelled with inward names is rated as more palatable (Rossi et al., 2017). Overall, only very few studies deviated from this paradigm. As one example, Topolinski and Boecker (2016a) demonstrated that instead of words one might also use mere consonant sequences (e.g., BK, KB) which show the same empirical in-out difference in stimulus evaluation. Thus, from an empirical perspective, the articulatory in-out effect in the paradigm of Topolinski et al. (2014) has proven to be quite robust. But does this also provide strong support for the underlying mechanism of articulation trajectory preferences?

Most in-out effect research derived its hypotheses from the initial oral approach/avoidance theory by Topolinski et al. (2014), namely the similarity of inward/outward trajectories with motor patterns of food consumption. Later research proposed an alternative theory that inward trajectories are simply more fluent, that is easier to articulate (Bakhtiari et al., 2016; Ingendahl et al., 2021; Körner et al., 2019). As fluency is a hedonically positive experience (Reber et al., 2004), the theory states that the (supposedly) higher fluency of inward trajectories leads to the more positive evaluation. Still, both the oral approach/avoidance and the fluency theory assume that it is the preferences for the articulation trajectories that lead to the empirical in-out effect. And even though some predictions of these theories and their specific processes were not supported in later studies, the crucial role of articulation trajectories in preference formation was never questioned (Bakhtiari et al., 2016; Garrido et al., 2019; Godinho, Garrido, Zürn, et al., 2019; Godinho & Garrido, 2020; Ingendahl et al., 2021; Körner et al., 2019; Maschmann et al., 2020; Topolinski & Bakhtiari, 2016).

Consonant Preferences as Alternative Explanation

Recently, however, an alternative explanation was proposed that can account for all of these findings and assumes a process independent of articulation trajectories. Concretely, Maschmann and colleagues (2020) proposed that there is no preference for inward trajectories, but merely a preference for front consonants (e.g., B, M, P) over rear consonants (e.g., G, K, R). The authors argue that this preference is also stronger if the consonants appear at the beginning of a word than at later positions within a word. Hence, according to this view, the preference for an inward word (e.g., BODIKA) over an outward word (e.g., KODIBA) is due to the isolable preference for the front consonant B over the rear consonant K, which has a stronger influence at the beginning than the end of the word. Notably, the preference for consonants enables further predictions. A word with the consonant sequence B-M (two front consonants) should even be preferred to B-K, with one front and one rear consonant, but an inward trajectory. Also, words with a sequence such as K-B (with one rear and one front consonant and also an outward trajectory) should be preferred to K-R (two rear consonants). The origin of such consonant preferences is unknown, but Maschmann et al. (2020) discuss that it might come from early language acquisition, which usually starts with front consonants. The authors provide solid evidence for such consonant preferences over a series of experiments (Maschmann et al., 2020). Thus, the research of Maschmann et al. (2020) implies that word preferences found in the context of the empirical in-out effect were not driven by preferences for articulation trajectories, but merely by a preference for front consonants that is more pronounced if a consonant is at the beginning of the word.

This is surprising, as there are earlier findings inconsistent with the consonant preference account of Maschmann et al. (2020): In an article on the original oral approach/avoidance theory, Topolinski and Bakhtiari (2016) constructed fictional words that consisted of either inward-outward trajectories or outward-inward trajectories. Typical exemplars were FOLOKOLOF for an inward-outward word, and KOLOFOLOK for an outward-inward word. According to the consonant preference account, one should expect that FOLOKOLOF (starting and ending with a front consonant) is evaluated more positively than KOLOFOLOK (starting and ending with a rear consonant). However, the opposite turned out over a series of five experiments: Words like KOLOFOLOK were preferred to words like FOLOKOLOF, despite the starting and ending front consonant of FOLOKOLOF and the starting and ending rear consonant of KOLOFOLOK. Topolinski and Bakhtiari (2016) explained this in terms of the oral approach/avoidance theory, such that inward-outward words like FOLOKOLOF resemble articulation trajectories associated with negative disgust (i.e., food is consumed and spit out immediately).

This raises the question why Maschmann et al. (2020) find the opposite pattern in their experiments. To answer this, one might consider a methodological detail in the research of Maschmann et al. (2020): In contrast to the standard in-out effect paradigm (e.g., Topolinski et al., 2014), the authors used combinations of consonants separated by underscores (e.g. _B_ _ _ _M_, _B _ _ _ _K_, _K_ _ _ _B_, _K _ _ _ _G_) as stimulus materials in their critical Experiments 9 and 10. Thus, the consonant-preference account was tested on word fragments consisting of single letters, but not on words. On a purely conceptual level, the clear-cut operationalization and design of Maschmann et al. (2020) are optimal for testing consonant preferences and their effect on stimulus preferences. However, is this paradigm also suitable to test the idea of articulation trajectory preferences?

Limiting Conditions for Articulation Trajectories

Whether word fragments are a suitable paradigm to study articulation trajectory preferences is a question of the operationalization’s construct validity (Fabrigar et al., 2020). In this instance, two requirements have to be met: First, fragments like _B _ _ _ _K_ would need to follow an inward/outward articulation trajectory, despite the removal of all letters except the first and the last consonant. If that requirement is met, the second requirement is that this trajectory is mentally represented in an embodied way to influence stimulus evaluation.

Regarding the first requirement, it remains uncertain how word fragments like B _ _ _ _ K would actually be articulated. The main challenge is that consonants require the partial or complete blocking of air stream and cannot be combined in any random cluster. For several consonant clusters, articulation is avoided unless vowels are inserted in between (e.g., Bruck & Treiman, 1990). In the studies by Maschmann et al. (2020), German participants were exposed to two classes of consonants: the sonorants [m] and [r], and the plosives [p], [b], [k], [g]. Except for the clusters "plosive + [r]", none of the consonant clusters exist in German at word onset positions (*Erweiterte Suche - OpenThesaurus*, 2020). For these unfamiliar consonant clusters, a default articulation is not available, so for articulation to be possible, participants would have to find alternative strategies:

As one workaround, participants might incidentally self-generate a full trajectory when exposed with such word fragments. For example, they could spontaneously add the spoken vowel as in the alphabet (i.e., [biː], [keɪ] in English or [be], [ka] in German). Thus, BK might be articulated the same as "BEKA" in German, which indeed is like a short inward trajectory. In fact, such a self-generated trajectory might even lead to stronger effects compared with actual words (Slamecka & Graf, 1978). However, Maschmann et al. (2020) explicitly instructed participants not to complete the word fragments, but to rate them as presented. Still, strong over-learning throughout one's life might lead to the spontaneous generation of articulation trajectories even when no articulation of words takes place.

As a second workaround, participants might have split the articulation into two separate components, one for each consonant. In this example, BK could be uttered as [b] – break – [k]. Due to this break, there is no continuous trajectory from front to rear consonants (or vice versa), but merely the separate articulation of two consonants. Under these circumstances articulation trajectory preferences cannot influence the evaluation of such consonant pairs. Support for this can be seen in an experiment by Topolinski and Boecker (Experiment 4; 2016a) where participants were presented with letter pairs like “BK” or “KB” auditorily: If the speaker only uttered the specific consonant (“[bk]”), no difference in evaluation for “BK” and “KB” was found. However, once the speaker used the articulation of spelling the consonant, uttered along with its spoken vowel as in the alphabet (“[beka]”), the traditional in-out effect was found[1].

Finally, even if the word fragments by Maschmann et al. (2020) actually followed consistent inward/outward trajectories, it remains uncertain whether they were mentally represented in an embodied way. In the last decades of embodied cognition research, several theories have proposed that linguistic stimuli are processed by two different systems – an amodal and a modal system (e.g., Barsalou et al., 2008; Dove, 2011; Mahon, 2015; Mahon & Caramazza, 2008). As an example, the Language And Situated Simulation (LASS) Model proposes that language is processed by a linguistic system and a simulation system (Barsalou et al., 2008; Simmons et al., 2008). According to this model, a word-like stimulus should be processed first in the amodal linguistic system where associations with the linguistic stimulus are retrieved in a superficial manner. The second system of the LASS model, the modal simulation system, has its activation peak later than the linguistic system and simulates the perceptual/motor states when interacting with the stimulus. In case of the word fragments of Maschmann et al. (2020), a fragment would thus be processed first in the linguistic system

[1] In other studies, Topolinski and Boecker (2016) presented these letter pairs visually, which led to a robust preference for front-rear (“inward”) over rear-front (“outward”) letter pairs. These results are compatible with both consonant preferences and articulation trajectories, if we assume that the articulation trajectory is not split into two components here. Unfortunately, Maschmann et al. (2020) did not use front-front, front-rear, rear-front, rear-rear letter pairs in any of their studies to test whether results on letter pairs (without underscores) can actually be explained by consonant preferences or not.

where linguistic associations are retrieved – such as the consonants within the fragment and the liking towards them. Next, the articulation trajectory of the fragment would be simulated in the simulation system which should trigger liking/disliking for the trajectory.

Crucially, the LASS model predicts that in those instances where linguistic associations are sufficient to solve a task, processing relies mostly on the linguistic system (Barsalou et al., 2008; Solomon & Barsalou, 2004). Evaluating word fragments might not require the simulation system because one could merely evaluate the associated consonants in isolation, and then integrate those evaluations into an overall liking judgment. The pronounceable pseudowords used in previous in-out effect research are more complex. Here, the model would predict a stronger influence of the simulation system, making it more likely that stimulus evaluation is influenced by the articulation trajectory. Thus, it is very well possible that the stimulus evaluations in the studies of Maschmann et al. (2020) were largely based on linguistic processing and thus reflected liking of the two consonants, whereas the evaluation of words used in previous in-out effect research rather relied on simulation processing and thus the liking of the articulation trajectory.

In conclusion, there are some indicators that the word fragments used by Maschmann et al. (2020) were not construct valid to critically test whether the in-out effect can be explained by articulation trajectory preferences: It remains uncertain whether the word fragments elicited articulation trajectories, and if they did, whether they were processed in an embodied manner. Thus, the current evidence might not provide a conclusive answer to the question whether preferences for articulation trajectories exist or whether previous findings in in-out effect research were actually based on preferences for consonants.

Goals of the Present Research and Hypotheses

In this research, we test the role of consonant preferences against articulation trajectory preferences in the articulatory in-out effect. A thorough test of these explanations is an important endeavor: Although the idea of articulation trajectories is rather new, having first been proposed in 2014, a lot of research has been inspired by it, conducted and also well received since then. A conclusive test of both accounts would show whether the original research merely investigated an epiphenomenon caused by consonant preferences, or a unique psychological consequence of articulation trajectories. In this vein, the present research seeks to solve the puzzle of mixed findings on the in-out effect. As we will discuss later, mixed findings do not rule out the relevance of either account, but could eventually be integrated into overarching models of embodied cognition, thus promoting the theoretical advance in the field.

To provide such a test, we conceptually replicated the critical Experiment 9 of Maschmann et al. (2020). In their study, participants evaluated consonant sequences of front and rear consonants that were divided by underscores (e.g., _B_ _ _ _ K _) with the articulation spot of the first consonant and the last consonant manipulated orthogonally (e.g., BM, PK, KM, KG). We used the same design with the same number of rated stimuli, but added the following crucial difference: To use materials for which articulation trajectories are more likely to influence stimulus liking than in the studies of Maschmann et al. (2020), we went back to the original in-out effect paradigm (Topolinski et al., 2014) and used pseudowords instead of word fragments. To still be in line with the research of Maschmann et al. (2020) as much as possible, we used the same front and rear consonants, but generated pseudowords by including three vowels and a middle consonant (e.g., L, D, T) in a word. As an example, a front-front word would be BODIMA, a front-rear (and also classical inward) word would be BODIKA, a rear-front (and also classical outward) word would be KODIBA, and a rear-rear word would be KODIGA. In such a design, one would expect the following:

Based on the consonant preference account, word preferences should be driven by the preference for front vs. rear consonants which is more pronounced if the respective consonant is presented at the beginning of the word. Front-front words like BODIMA have two front consonants (one as the first and one as the last consonant) and should thus be rated better than all other word types. If indeed the type of consonant has a smaller effect at the ending of a word, this would imply that front-rear (or: classical inward) words such as BODIKA are liked a little less than front-front words, because they have a rear consonant instead of a front consonant at the word's ending. However, front-rear words should still be liked more than rear-front (or: classical outward) words because according to Maschmann et al. (2020), the front consonant at the inward word's beginning should have more impact than the front consonant at the outward word's ending. Finally, rear-rear words should be rated the least favorable because they have rear consonants at both word beginning and ending. Thus, one would expect the following ordinal pattern in the mean evaluation:

H1: front-front > front-rear (inward) > rear-front (outward) > rear-rear.

In contrast, the original idea of an effect based on articulation trajectories predicts the following: If a word entails a full inward trajectory (i.e., a front-rear word such as BODIKA), it should be preferred to one that is neither fully inward nor fully outward (i.e., front-front words and rear-rear words such as BODIMA or KODIGA), which should still be preferred to a full outward word (i.e. a rear-front word such as KODIBA). Thus, on that basis one could expect that front-rear (inward) words are actually preferred over front-front words, and rear-rear words are preferred over rear-front (outward) words.

In addition to these clear predictions derived from the articulation trajectory account, one may even speculate about differences between front-front words and rear-rear words. Following the rationale by Topolinski and Bakhtiari (2016) – namely that words with an inward-outward trajectory resemble motorial patterns associated with ingesting and spitting out food immediately whereas words with an outward-inward trajectory do not – front-front words like BODIMA actually resemble a short inward-outward trajectory ("BOD-DIMA").

Thus, they might be liked even less than rear-rear words such as KODIGA which resemble a short outward-inward trajectory. However, this assumption rests on only one of the two original theories on articulation trajectory preferences and this theory has not received supporting evidence in other experiments by Maschmann et al. (2020). Additionally, due to the extreme shortness of both trajectories the difference might be rather weak. Therefore, we do not formulate it as an explicit addition to our second hypothesis, but leave open whether evaluations differ between rear-rear and front-front words. Overall, one should expect the following ordinal mean pattern if the in-out effect is based on articulation trajectories:

H2: front-rear (inward) > (rear-rear, front-front) > rear-front (outward)

We preregistered our design, with all materials and code, on the OSF: https://osf.io/k3q9t/?view_only=a68331c9406f4a63b99446cf234e928a.
Additionally, all materials, code, and analysis scripts together with the data are provided in this OSF directory: https://osf.io/5dzqw/?view_only=5b3520a4f8134d4690e46505419affe4.

Methods

Design & Procedure

This experiment followed a within-subjects design with the factor word type (front-front vs. front-rear vs. rear-front vs. rear-rear). German-speaking participants answered a short online survey on Prolific Academic. After an informed consent page, participants evaluated 96 fictional words (24 per word type) in random order, by answering the question “How much do you like this word?” on a rating scale from 0 (I do not like it at all) to 10 (I like it very much) coded as 1-11. Each word was presented on a single screen. After that task, participants provided sociodemographic data. Finally, they were asked about the study purpose and whether they identified a system behind the words before they were debriefed, thanked, and dismissed. The study took approximately eight minutes and participants were paid 1.10£. The full questionnaire can be found in the preregistration and in the OSF directory.

Materials

We used the word fragments from Maschmann et al. (2020; Experiment 9) as a basis for our materials. These fragments were built from the front consonants B, P, M, and the rear consonants G, K, R. To form pronounceable words from these fragments, we also included the three middle consonants D, T, and L, and all German vowels (A, E, I, O, U). To avoid systematic confounds between the different word types, we randomly generated words for each participant. Thus, following the procedure of Ingendahl et al. (2021), each of these consonant lists was randomly mixed for each participant, and the words were constructed ad-hoc with the following approach:

Front-front words were generated by taking the first random front consonant (e.g., B) and combining it with each of the middle consonants and the two remaining front consonants (e.g., M, P). The same was done for the second front consonant (e.g. M). Thus, there were 2 x 3 x 2 = 12 different consonant sequences (i.e., BLM, BLP, BDM, BDP, BTM, BTP, MLB, MLP, MDB, MDP, MTB, MTP). Each consonant sequence was used twice to generate a word, by inserting vowel 1, 2, 3, and 3, 4, 5 from the randomized vowel list after each consonant. As an example, the consonant sequence BLM might have led to the words BOLIMA and BALUME. A full exemplary stimulus set for a participant can be found in Table 1.

Front-rear words were generated with the same approach, but each of the second front consonants was replaced by a rear consonant, again leading to 12 different consonant sequences (i.e., BLK, BLG, BDK, BDG, BTK, BTG, MLR, MLG, MDR, MDG, MTR, MTG). Rear-front words were generated like front-rear words, but with front consonants instead of rear consonants and vice versa (i.e., RLM, RLP, RDM, RDP, RTM, RTP, KLB, KLP, KDB, KDP, KTB, KTP). Rear-rear words were built following the same approach as front-front words, but with rear consonants instead of front consonants (i.e., RLK, RLG, RDK, RDG, RTK, RTG, KLR, KLG, KDR, KDG, KTR, KTG).

In sum, this resulted in 96 words (24 per word type) which is the same amount of stimuli as in the original study. A full stimulus set that could originate from our material generation is provided in Table 1.

Table 1

Sample Stimuli Resulting from the Material Generation for a Single Participant.

Word Type	Stimuli
front-front	BOLIMA, BALUME, BELIPO, BOLUPA, BUDIME, BEDOMA, BEDAPU, BUDIPO, BETAMO, BOTUMI, BATIPE, BETUPO, MELIBO, MOLUBA, MOLUPA, MALEPI, MIDUBO, MODEBA, MUDAPE, MEDOPI, MATIBO, MOTUBE, MITAPU, MUTOPE
front-rear (inward)	BELIKU, BULAKO, BELAGI, BILOGU, BADEKO, BODIKU, BODEGA, BADIGU, BUTEKA, BATOKI, BITEGO, BOTUGA, MELIRO, MOLARU, MULEGA, MALOGI, MIDARO, MODURE, MADOGE, MEDUGI, MOTARI, MITURE, MUTAGO, MOTIGE
rear-front (outward)	RELIMO, ROLUMA, RULEPI, RILOPA, RADEMO, RODUMI, RIDEPA, RADOPU, RITEMO, ROTUMA, ROTAPU, RUTIPE, KULIBO, KOLABE, KALUPI, KILOPE, KEDABO, KODIBU, KUDAPE, KEDIPO, KITEBO, KOTABU, KUTEPA, KATOPI
rear-rear	RELIKO, ROLUKA, RULAGI, RILOGE, RADOKI, RIDEKU, RUDIGE, REDAGO, ROTEKI, RITUKA, RETUGA, RATOGI, KILARE, KELURO, KOLIGA, KALUGE, KUDERI, KIDORA, KADOGE, KEDUGI, KETARI, KITURO, KATIGO, KOTEGU

Note. Words are generated randomly and thus differ between participants.

Analysis Plan and Sampling Strategy

For a straightforward test of the two hypotheses, we used informative hypothesis evaluation with Bayes Factors as inference method (Hoijtink et al., 2019). Crucially, this method enables a test for the whole ordinal mean patterns predicted by the hypotheses, rather than tests of multiple paired comparisons or linear contrasts which assume specific differences between means. Moreover, the method enables sequential recruiting and testing methods, thus collecting data until a certain degree of evidence is reached (Hoijtink et al., 2019; Schönbrodt et al., 2017; Schönbrodt & Wagenmakers, 2018).

Within this Bayesian approach, we conducted an analysis of variance (ANOVA) for repeated measures in the R package Bain (Gu et al., 2019; Hoijtink et al., 2019), with the informative hypotheses H1 and H2 as specified in the theory section and default priors. Afterwards, we used Bayes Factors (BF) to evaluate the evidence, with BF_{1u} and BF_{2u} as well as BF_{12} for evaluating the hypotheses. BF_{1u} is the Bayes Factor for Hypothesis 1 in comparison to the so-called unrestricted hypothesis, which is that the means may or may not differ somehow from each other (H_u: front-front, front-rear, rear-front, rear-rear). In our design, it was rather certain that the means differ somehow because of the robustness of inward and outward word differences in previous research. Thus, we decided to perform a strict test of the hypotheses by testing against this uninformative unrestricted hypothesis instead of the standard null hypothesis (all means are exactly equal). Additionally, we used the posterior model probabilities (PMP) to quantify the uncertainty that comes with the decision for a specific hypothesis.

We used sequential recruiting and testing methods (Hoijtink et al., 2019; Schönbrodt et al., 2017; Schönbrodt & Wagenmakers, 2018). With sequential methods in a Bayesian framework, one can collect data until a desired degree of evidence or a maximum sample size (determined by a minimum effect size of interest or recruitment resources) is reached. In the latter case, the results from the final sample are evaluated nevertheless. Due to practicality reasons, we recruited in steps of 25 participants, starting at *N* = 50. Following the preregistration protocol, we considered only complete data sets for the analysis. After each step of recruitment, we immediately excluded all participants who

a) explicitly referred to the in-out effect or oral inward/outward movements when being asked about the study purpose,

b) answered redundantly (e.g. only responding with 5) on more than 64/96 words.

We planned to terminate data collection once one of the following criteria was achieved:

a) BF_{1u} or BF_{2u} > 30 and at the same time PMP_1 or PMP_2 > 90%
b) A maximum sample size of *N* = 350 was reached.

The maximum sample size was chosen based on a power analysis for a frequentist paired samples t-test with $d_z = 0.2$, $\alpha = .05$, and $(1-\beta) = .95$ in G*Power (Faul et al., 2007). The termination criterion a) also needed to apply for a robustness check: Our ad-hoc stimulus generation might have led to some inward/outward words that were identical or homophone to existing German words. To control for this, we reran the same analysis with a restricted stimulus set where all existing or homophone words (e.g., “BELUGA”, “BATERI”) were excluded (see Ingendahl et al., 2021, for a similar approach in in-out effect research.).

To show that such a sampling and analysis strategy was justified here, we ran a Monte Carlo simulation in R to test the influence of, priors, sample size, and the actually true hypothesis on the Bayes factors and the posterior model probabilities. This simulation with its results can be found in the Supplementary Procedure[2].

[2] Due to a programming mistake in our initial preregistered simulation, our sequential testing procedure was very conservative with a Bayes Factor of 30 as a termination criterion. In

Recruitment Process and Participants

The Bayes Factors at each recruitment step can be found in the Supplementary Procedure. BF_{1u} approached 0 fast, whereas BF_{2u} increased steadily. The threshold of 30 was never reached for either of the Bayes Factors, which led to recruitment of the full 350 participants, even though the posterior model probability of 90% for H2 had been reached with $N = 200$.

Over the recruitment process, four participants had to be excluded because of redundant answering (> 64/96 times the same answer). None of the participants mentioned or described the in-out effect when asked about the study purpose, and also none of the participants indicated a system of in-out mechanics, even when asked about the systematics behind the words. However, between N = 275 and N = 300, a participants' dataset was lost (according to the panel data he/she participated, but there was no dataset).

Thus, our final sample consisted of 349 participants (203 male, 142 female, 4 diverse, $M_{age} = 29.11$, $SD_{age} = 9.42$). Nearly all of them were native speakers (98.28%), with half of them being students (41.83%).

Results

Main Analysis

All code for our analysis is provided in the OSF directory. The mean evaluation of the four word types is depicted in Figure 1. Front-rear (inward) words were evaluated more positively than the other three word types, followed by rear-rear words, then front-front words, and finally rear-front (outward) words. These results are perfectly consistent with the

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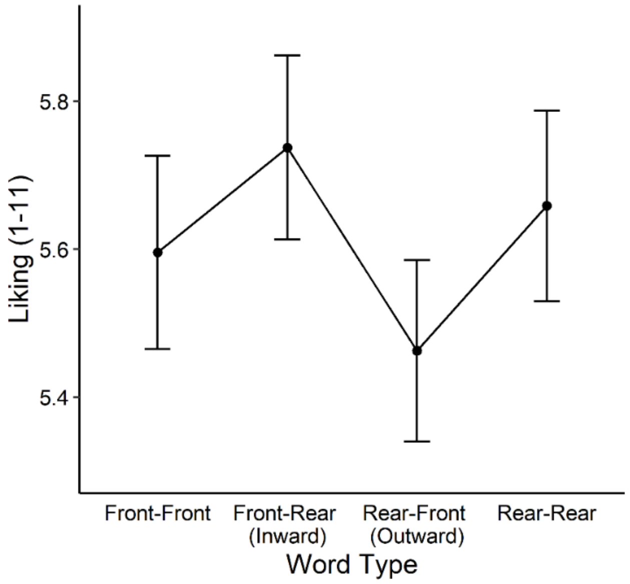
hindsight, a Bayes Factor of 10 would have been sufficient (see the Supplementary Procedure for details).

articulatory trajectory account, but not with the consonant preference account. Thus, our Bayesian ANOVA revealed that H1 was not supported well by the data in comparison to the unrestricted hypothesis, BF_{1u} = 0.00, PMP_1 = .00. However, H2 had better support than the unrestricted hypothesis, BF_{2u} = 10.36, PMP_2 = .91. Thus, H2 was clearly superior to H1, BF_{21} = 283261088, providing strong support for the articulatory trajectory account.

Figure 1

Mean Word Liking by Word Type (N = 344).



Note. Error bars depict 95% Credibility Intervals from the Bain ANOVA.

Robustness Check

Following the preregistration protocol, we conducted the same analysis after excluding words that were identical or homophonous to existing German words (12 overall). The Bayesian ANOVA led to results nearly identical to the main analysis and is thus only provided in the OSF directory[3]. We also conducted the same frequentist ANOVA as done by Maschmann et al. (2020), together with an additional contrast analysis. Both lead to the same conclusions as our main analysis, thus they are only reported in an Online Supplement.

Exploratory Analyses

Last, we computed pairwise comparisons between all word types with Bayesian t-tests conducted with the BayesFactor package (Morey & Rouder, 2018) and default priors. The resulting Bayes Factors of these t-tests are displayed in Table 2.

Table 2

Bayesian T-Tests Comparing the Mean Liking of Different Word Types

Comparison	d_z	BF_{10}
front-front vs. front-rear	-0.20	62.19
front-front vs. rear-front	0.16	5.60
front-front vs. rear-rear	-0.06	0.11
front-rear vs. rear-front	0.34	6627226
front-rear vs. rear-rear	0.09	0.28
rear-front vs. rear-rear	-0.28	24567.58

Note. d_z = standardized difference score, BF = Bayes Factor.

General Discussion

A plethora of research has studied articulation trajectory preferences and their influence on stimulus liking, which has come to be known as articulatory in-out effect (Topolinski et al., 2014). Recently, Maschmann et al. (2020) proposed that findings from this

[3] In addition to the reported preregistered analyses, we also checked for prior sensitivity as recommended by Hoijtink et al. (2019) by setting the prior fraction to 3 instead of 1. None of the results changed, therefore the results are only provided in the OSF directory.

research were actually not due to preferences for articulation trajectories, but a mere epiphenomenon caused by consonant preferences: People prefer front over rear consonants, and this preference is stronger for consonants at the beginning of a stimulus. We argued that the materials used by Maschmann et al. (2020) might have prevented influences of articulation trajectories on stimulus liking. We conducted a high-powered conceptual replication of the critical Experiment 9 of Maschmann et al. (2020), thus keeping the essential characteristics in Maschmann et al. (2020). At the same time, we used words instead of word fragments, thus providing optimal conditions to elicit articulation trajectories. In our experiment, we find no evidence for the consonant preference account, but solid evidence for the original idea of preferences for articulation trajectories: Words with front consonants as both the first and the last consonant were evaluated worse than inward words that have a front consonant as the first and a rear consonant as the last consonant. Also speaking against the consonant-preference account, words with a rear consonant both as first and last consonant were preferred to outwards word with a rear consonant first and a front consonant last. Replicating the empirical in-out effect, inward words were preferred to outward words.

Thus, the major implication of this research is that consonant preferences cannot explain the word preferences found in previous in-out effect research. Our findings imply that the original research has actually studied a valid theoretical concept of articulation trajectory preferences, and not just an epiphenomenon of consonant preferences. Thus, we find support for a theoretical idea that has been the basis for a considerable amount of research (e.g., Garrido et al., 2019; Gerten & Topolinski, 2018; Godinho, Garrido, Zürn, et al., 2019; Godinho & Garrido, 2016, 2019, 2020; Ingendahl et al., 2021; Körner et al., 2019; Lindau & Topolinski, 2018b; Maschmann et al., 2020; Rossi et al., 2017; Silva & Topolinski, 2018; Topolinski et al., 2014, 2015; Topolinski & Bakhtiari, 2016; Topolinski & Boecker, 2016a, 2016b).

Our research offers valuable implications in many aspects. First, it implies that future research must further investigate where these trajectory preferences come from. Previous in-out effect research has proposed two theories to explain trajectory preferences. Despite the strong support for the idea of articulation trajectory preferences in our study, our findings also provide some challenges for these theories which we will discuss first. Second, there might be further theoretical reasons why our results diverge from Maschmann et al. (2020), which we will discuss afterwards. Last, we will also discuss the limitations of our research.

Implications for Theories on Articulation Trajectory Preferences

In previous research, two theories on articulation trajectory preferences were offered: The original oral approach/avoidance theory that inward/outward trajectories are associated with the motor dynamics of food deglutition/expectoration (Topolinski et al., 2014), and the fluency theory that inward trajectories are more fluent than outward trajectories (Bakhtiari et al., 2016). Though the present research did not aim at pitting them against each other, our findings also challenge some assumptions of the two theories:

Concerning the oral approach/avoidance theory, we mentioned previous research that investigated word preferences for compounds of inward-outward and outward-inward words (FOLOKOLOF vs. KOLOFOLOK; Topolinski & Bakhtiari, 2016): Outward-inward words are preferred to inward-outward words. In our case, front-front words such as “BODIMA” consist of a very short inward and a very short outward trajectory, whereas for rear-rear words (“KODIGA”), there is first an outward and then an inward trajectory. Despite high statistical power, we only found a small descriptive preference for rear-rear over front-front words in our data. On the one hand, this could be due the shortness of the inward and the outward trajectory, which might have prevented the necessary motor experience. On the other hand, one could argue that this is inconsistent with the oral approach/avoidance theory: Especially if food is tasted briefly with the tip of the tongue and then spit out immediately, similar to the movement of articulating a front-front word like BODIMA, it signals that this food was likely inedible or poisonous. This interpretation would be consistent with further experiments conducted by Maschmann et al. (2020) that did not find any support for the oral approach/avoidance theory (e.g., that food deprivation or disgust induction do not alter the in-out effect).

However, our results also suggest some refinements for the fluency theory proposed later (Bakhtiari et al., 2016). Corpus analyses (Bakhtiari et al., 2016) have revealed that front consonants are more common at starting positions in words (23.3% front vs. 18.7% rear), and rear consonants are more common at ending positions (5.5% front vs. 20.3% rear). The initial fluency theory assumes that these different ecological frequencies lead to the fluency advantage of inward trajectories. Our research suggests that such frequencies might not be specific enough to explain trajectory preferences, because the position of a single consonant itself seems to be unimportant for word preferences. Instead, the frequency-based explanation would need to assess the combination, that is whether front-rear combinations are more prevalent than rear-front combinations, etc.

Yet, as a rough approximation of combination frequencies, one could multiply the probabilities from Bakhtiari et al. (2016). Thus, if one follows the logic of the original frequency-fluency explanation and assumes that the frequency of front-front, front-rear, etc. combinations in natural language can be derived from such information by multiplication (e.g., p(front-front) = 23.3% × 5.5%), one would observe a higher frequency and thus higher fluency of inward over outward words. However, the same frequency-fluency explanation would also predict that rear-rear words are more fluent and more positive than front-front words – which we do not find in our study. Overall, our findings are consistent with recent evidence to suggest that the fluency advantage of inward trajectories is not driven by exposure to inward/outward words (Ingendahl et al., 2021).

Articulation Trajectories, Consonants, or Both?

While our findings lend clear support for the idea that articulation trajectories influence word liking, the divergence from Maschmann et al.'s (2020) results calls for further attention. After all, they provide strong evidence for consonant preferences and their influence on the evaluation of word-like stimuli. By introducing only a small change in the operationalization – using pseudowords instead of word fragments – we find systematically different results. This does not mean that one of the studies is a false positive. Instead, it is possible that both trajectory preferences and consonant preferences are separate processes, and their contribution to the empirical in-out effect may vary across situations. Future research must therefore identify the psychological states that moderate the impact of consonant vs. trajectory preferences. In that sense, our results might point into some first directions:

One condition for trajectory preferences merely at the level of operationalization might be an uninterrupted articulation trajectory. As discussed in the beginning, consonants divided by underscores might simply not fulfill this requirement, and participants might split the articulation into different parts. This interpretation would raise the question whether previously found preferences for mere consonant sequences (e.g., BK, KB) are the result of consonant preferences as well (Topolinski & Boecker, 2016a). To further investigate the role of an uninterrupted trajectory, one could ask participants to articulate such consonant sequences (e.g., BK, KB) aloud. This would allow for a systematic investigation of how spontaneous articulation trajectories might occur nevertheless (e.g., which vowels or consonants are interpolated), in which cases full inward or outward articulation trajectories are actually present and, finally, whether stimulus evaluation depends on the presence of an actual trajectory.

The next logical question is whether articulation trajectory and consonant preferences could be integrated into an overarching theory. A promising way of integrating the results is by considering dual-representation theories such as the LASS (Barsalou et al., 2008; Simmons et al., 2008). From their perspective, stimuli with inward/outward trajectories might not always be represented in a modal simulation system, but also in an amodal linguistic system. One could derive further predictions from such models: As an example, the LASS assumes that the linguistic system has its maximum activation peak before the simulation system. Thus, speeded word evaluation tasks should strengthen processing in the linguistic system, leading to a stronger impact of consonant preferences in stimulus evaluation. Furthermore, one could revisit a research idea from previous in-out effect research (Lindau & Topolinski, 2018a): Under oral motor interference (e.g., chewing gum), simulation processes should be disrupted, leading to effects of the linguistic system and thus stimulus evaluation driven by consonant preferences.

In fact, such a broadened perspective within larger theoretical frameworks would benefit in-out effect research in general. After the seminal publication of Topolinski et al. (2014), research slowly drifted away from investigating the original theoretical idea of trajectory preferences to establishing the robustness of an empirical difference in word preferences. This research relied on direct or close replications within the paradigm of Topolinski et al. (2014), which were certainly helpful for understanding whether the empirical in-out effect exists (Fabrigar & Wegener, 2016; Simons, 2014). However, the in-out "effect" is merely an arbitrary instantiation or operationalization of a principle that could be tested with completely different materials and procedures. For actual epistemic progress, deviation from established paradigms ("loosening") is necessary (Fiedler, 2018; Fiedler et al., 2012), as realized by Maschmann et al. (2020): They developed a broader theory to explain previously found effects, extended the established in-out effect paradigm to other stimulus types (front-

front, rear-rear) to test it and successfully showed that other processes than trajectory preferences play a role in the evaluation of linguistic stimuli (Maschmann et al., 2020). And even though our findings eventually show that their theory does not explain the effects within the established word preference paradigm, this debate leads to a stronger focus on the assumed theoretical processes and integrative theorizing about when and how proprioceptive feedback may play a role in attitudinal judgments (see also Noah et al., 2018).

Limitations

Our research has several limitations. First, we only conducted a single experiment. Despite being highly powered and providing a conclusive test for two accounts at the same time, further replications of our findings should be considered for future research. Second, and linked to the previous point, our findings were only shown for a sample of German native speakers. However, the studies of Maschmann et al. (2020) were also conducted only with Germans, which is why we chose a similar sample. As trajectory preferences have also been studied in other languages such as Portuguese (Godinho & Garrido, 2016), Ukrainian, and Turkish (Godinho, Garrido, & Horchak, 2019), future studies should be conducted on samples with other native languages. In addition, consonant preferences but also the familiarity of consonant clusters might differ between languages, providing a further opportunity to test the idea of consonant preferences. Third, our study deviated from the original Experiment 9 of Maschmann et al. (2020) by using an online instead of a lab experiment. However, their next experiment with a similar design also had an online sample and showed the same results as Experiment 9. Therefore, using an online experiment in our study is justified. Last, the observed effect sizes are very small. This might be due to the random generation of words, which creates high internal validity, but also more noise compared to using the same fixed words for all participants. However, the size of the inward-outward difference is comparable to previous research (Topolinski et al., 2014).

Conclusion

Once again, the idea that articulation trajectories influence word liking was supported. We show that previous studies did not observe a mere epiphenomenon of consonant preferences. Therefore, researchers should not give up on the idea of articulation trajectory preferences, as it is worthwhile to further investigate in future research. When doing so, however, broader theories and paradigms that go beyond studying word preferences should be developed.

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Case Report

The articulatory in-out effect: Driven by articulation fluency?☆

Moritz Ingendahl[a,*], Tobias Vogel[b], Michaela Wänke[a]

[a] Dept. of Consumer & Economic Psychology, University of Mannheim, A5,6 B129, 68159 Mannheim, Germany
[b] Dept. of Social Sciences, Darmstadt University of Applied Sciences, Haardtring 100, 64295 Darmstadt, Germany

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ABSTRACT

People prefer linguistic stimuli with an inward-wandering consonant sequence (e.g., PATIKO) over those with an outward-wandering consonant sequence (e.g., KATIPO), a preference referred to as articulatory in-out effect. Previous research has proposed that this effect is based on a higher fluency of inward versus outward articulation. Recently, however, several keystones of this articulation fluency account have been called into question. In the present research, we provide a straightforward test for this account by extending the traditional in-out effect research design to include other sequences as well. This allowed comparing liking and articulation fluency judgments over a range of stimuli beyond merely inward vs. outward stimuli. The results of two highly powered experiments (N = 531, one preregistered) show that even though inward stimuli are more fluent and better liked than outward stimuli, over all stimulus types articulation fluency and liking judgments diverge. These findings imply that articulation fluency alone cannot account for differences in liking such as the in-out effect. We discuss further directions for future in-out effect research.

Which fictitious word do you like better – PATIKO or KATIPO? Research on the articulatory in-out effect predicts that most people prefer PATIKO. This effect describes the preference for linguistic stimuli with an inward-oriented consonant sequence over those with an outward-oriented consonant sequence (Topolinski, Maschmann, Pecher, & Winkielman, 2014). In case of PATIKO, a speaker first forms the [p] at the front of the mouth, next the [t] in the middle, and last the [k] in the rear of the mouth. Thus, the different articulation spots of the consonants (front, middle, rear) constitute an inward sequence. For the word KATIPO, the articulation spots are reversed (rear, middle, front), constituting an outward sequence. Words that contain such an inward sequence (e.g., BODIGA, MELIRU) are liked better than words containing an outward sequence (e.g., GODIBA, RELIMU), independent of the specific vowels used (Topolinski & Boecker, 2016).

Despite its recent discovery, the articulatory in-out effect has already sparked a lot of interest in social psychology (cf., Ingendahl, Vogel, & Topolinski, 2021; Topolinski, 2017). Many studies attest to its empirical robustness across languages, such as German, English, Portuguese, French, Turkish, and Ukrainian (e.g., Godinho & Garrido, 2016; Godinho, Garrido, & Horchak, 2019; Rossi, Pantoja, Borges, & Werle, 2017; Topolinski et al., 2014). Beyond mere stimulus liking, the effect has also been shown to manifest itself in social contexts, such as product choices (Topolinski, Zürn, & Schneider, 2015), judgments of a person's warmth (Garrido, Godinho, & Semin, 2019), or a person's trustworthiness (Silva & Topolinski, 2018). Yet, the causes underlying the phenomenon are still unknown.

1.1. The articulatory in-out effect and articulation fluency

One promising explanation for the in-out effect is fluency or more specifically articulation fluency (Bakhtiari, Körner, & Topolinski, 2016). Fluency is defined as the subjective experience of ease while processing a stimulus (cf., Oppenheimer, 2008). A prominent theory, catchily summarized as "Mind at ease puts a smile on the face", holds that this ease of processing elicits positive affect which is then misattributed on the respective stimulus, leading to a more positive evaluation (cf., Reber, Schwarz, & Winkielman, 2004; Winkielman & Cacioppo, 2001). Articulation fluency is one form of processing fluency that influences liking (Alter & Oppenheimer, 2006; Bakhtiari et al., 2016; Körner, Bakhtiari, & Topolinski, 2019; Laham, Koval, & Alter, 2012; Newman et al., 2014). For example, surnames that are easy to pronounce (e.g., "Atkinson") are judged more positively than names that are hard to pronounce (e.g.,

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* Corresponding author.
E-mail addresses: mingenda@mail.uni-mannheim.de (M. Ingendahl), tobias.vogel@h-da.de (T. Vogel), michaela.waenke@uni-mannheim.de (M. Wänke).

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"Leszczynska"; Laham et al., 2012).

Consistent with an articulation fluency account, Bakhtiari et al. (2016) found that indeed inward words are judged as easier to articulate than outward words. Furthermore, the in-out effect was partially mediated by articulation fluency judgments. Bakhtiari et al. (2016) also provided an ecological correlate of the higher fluency of inward articulation: Two corpus analyses revealed that inward sequences seem to be more frequent than outward sequences in both German and English language, which might lead to a fluency advantage of inward articulation. From these findings, articulation fluency seems a plausible explanation for the in-out effect.

Recently, however, this articulation fluency account was challenged by experimental findings: Artificial fluency training by articulating exclusively inward or exclusively outward stimuli does not modulate the in-out effect (Ingendahl, Schöne, Wänke, & Vogel, 2021). Further research has criticized the corpus analyses by Bakhtiari et al. (2016) for being too unspecific: Under strict criteria actual inward/outward sequences are so rare in natural language that they are unlikely to cause a fluency advantage of inward articulation (Ingendahl & Vogel, 2021). Other studies show that the in-out effect is not systematically influenced by other typical fluency manipulations such as figure-ground contrast (Godinho & Garrido, 2021) or by individuals' reliance on intuition and affect (Ingendahl & Vogel, 2022). Overall, these findings question the role of articulation fluency in the in-out effect and suggest that further research is needed to critically test this explanation.

In that respect, one limitation of previous research on the articulation fluency account has been the traditional in-out effect research design: When comparing the effect of only inward and outward stimuli on any dependent variable (e.g., liking, fluency, etc.) there are only three different possible patterns: inward > outward, inward < outward, or inward ~ outward. Such a narrow design is not very diagnostic to test a theoretical assumption and may lead to false illusions of causality (Fiedler, 2017). However, opening the paradigm to other conditions could already be enough to critically test – that is, to falsify – a theory.

As one recent example for such an extended paradigm in the domain of the in-out effect, consider research conducted by Ingendahl and Vogel (2021). They argued that if the in-out effect is indeed an effect of articulation trajectories, words that are a combination of inward and outward sequences should be liked less than pure inward words, but still liked more than pure outward words. In their study, participants evaluated *front-rear* words with a front consonant as the first and a rear consonant as the last consonant (with a middle consonant in between; e.g., BODIKA), thus constituting a pure inward articulation. Also, participants evaluated *rear-front* words with a rear consonant as the first and a front consonant as the last consonant (e.g., KODIBA), thus constituting a pure outward articulation. Crucially, participants also evaluated mixed sequences: *front-front* words with a front consonant both as the first and the last consonant (e.g., BODIMA). Note that in this case an inward sequence is followed by an outward sequence (i.e., BOD - DIMA). Analogously *rear-rear* words with a rear consonant both as the first and the last consonant combined first an outward with a subsequent inward component (e.g., KODIRA). As one would expect from the in-out effect as an effect of inward versus outward articulation trajectories, front-rear (inward) stimuli were evaluated most positively and rear-front (outward) stimuli least favorably, with the other two word types, front-front and rear-rear, on an equal average level between front-rear and rear-front.[1]

[1] Previous studies indicate that people sometimes prefer outward-inward sequences over inward-outward sequences (i.e., KOLOFOLOK > FOLOKOLOF; Topolinski & Bakhtiari, 2016). However, this finding was not replicated in the paradigm of Ingendahl and Vogel (2021) who argue that the inward and outward components (e.g., BOD - DIMA) in front-front and rear-rear words are too short to lead to systematic differences between the two types of mixed sequences.

This paradigm lends itself to test the articulation fluency account more critically: The essence of the articulation fluency account is that consonant sequences (such as front-rear and rear-front) differ in articulation fluency which then leads to differences in liking. This implies that the more fluent a consonant sequence is, the more it should be liked. However, this also implies that if two sequences are equally fluent then they should be equally liked. If they are equally fluent but differ in liking then mere articulation fluency cannot account for the differences in liking of the two sequences.

In the context of the extended paradigm of Ingendahl and Vogel (2021), this means that articulation fluency should also be highest for pure inward stimuli (e.g., BODIKA) and lowest for pure outward stimuli (KODIBA). Mixed sequences such as BODIMA and KODIRA should be less fluent than inward stimuli and more fluent than outward stimuli. In other words, if articulation fluency is responsible for the results obtained by Ingendahl and Vogel (2021) for liking, the pattern for articulation fluency should parallel that for liking. If the differences in articulation fluency between the word types do not parallel those of liking (e.g., both front-front and front-rear stimuli have equally high articulation fluency but differ in liking), mere articulation fluency cannot explain the in-out effect – even if the pure inward and outward stimuli differ both in fluency and liking. An articulation fluency account would therefore predict the following pattern for both, liking and articulation fluency judgments:

H1. Front-rear (inward) > (rear-rear; front-front) > rear-front (outward).

To test this hypothesis, we first provide an exact replication of the study by Ingendahl and Vogel (2021) in Experiment 1 – with measuring articulation fluency instead of liking. Next, we vary the type of judgment (articulation fluency or liking) between participants in Experiment 2.

2. Experiment 1

2.1. Methods

We report all measures, manipulations, and exclusions in both experiments.

2.1.1. Design & procedure

This investigation followed the exact same procedure and design of Ingendahl and Vogel (2021) but with articulation fluency as dependent variable. Thus, the experiment had the single factor word type (front-front vs. front-rear vs. rear-front vs. rear-rear). We recruited German-speaking participants on Prolific Academic to answer a short online survey, but we made sure that the samples did not overlap with the one used by Ingendahl and Vogel (2021). Participants received the same payment of 1.10£. After an informed consent page, participants rated 96 fictional words (24 per word type) in random order on articulation fluency. Each word was presented on a single screen. Participants were asked "How easy is it to pronounce this word?" and presented with a rating scale from 0 (not at all) to 10 (very much) coded as 1–11. This measure is established in in-out effect research (Bakhtiari et al., 2016; Ingendahl, Schöne, et al., 2021; Körner et al., 2019). Afterwards sociodemographic data were assessed. Participants were then asked about the study purpose and whether they identified a system behind the words before they were debriefed and dismissed. The full questionnaire can be found in the OSF directory.

2.1.2. Materials

The material generation procedure was identical to that of Ingendahl and Vogel (2021). For each participant 96 fictional pseudowords (24 per word type) were randomly built from the front consonant letters B, P, M, the middle consonant letters D, T, L, the rear consonant letters G, K, R, and all German vowels (A, E, I, O, U). Front-front words were generated by combining a front consonant (e.g., B) with a middle consonant (e.g.,

D) and another front consonant (e.g., M). After each consonant, a different vowel was inserted. For this, the five vowels were put in a random sequence and from this sequence either the first three or the last three vowels were taken. As an example, the consonant sequence BDM could result in the words BODIMA and BADUME. Front-rear (inward) words were generated by the same procedure, but with a rear instead of a front consonant as the last consonant (e.g., BADIKO). Rear-front (outward) words had a rear consonant as the first and a front consonant as the last consonant (e.g., KADIBO), and rear-rear words had two different rear consonants (i.e., RALIKO). A full stimulus set for a single participant is presented in Appendix A.

2.1.3. Analytical procedure & power

In line with the supplemental analysis by Ingendahl and Vogel (2021), we used polynomial contrasts to test our hypothesis. Our expected pattern should lead to a significant cubic contrast (front-front: -1, front-rear: 3, rear-front: -3, rear-rear: 1), whereas the linear ($3,1,-1,-3$) and the quadratic ($1,-1,-1,1$) contrasts should not be significant. Sample size was determined before any data analysis. As a rough approximation, we used the within-subjects ANOVA interface in G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) with $\alpha = 0.05$, $(1-\beta) = 0.9$, $r = 0.5$, and a small sample effect size ($f = 0.1$) which revealed a necessary sample size of $N = 179$. In case participants needed to be excluded, we decided to recruit 200 participants.

2.1.4. Participants

Our sample consisted of 201 German native speakers (109 male, 91 female, 1 diverse, $M_{age} = 31.5$, $SD_{age} = 10.83$, $Range_{age}$ [18; 68], 35% students). Following Ingendahl and Vogel (2021), we checked whether participants mentioned or described the in-out effect when asked about the study purpose, which was not the case.[2]

2.2. Results

In contrast to H1, front-front words were descriptively most fluent, directly followed by front-rear (inward) words, then rear-front (outward) words, and finally rear-rear words (see Fig. 1). Thus, the cubic contrast was not significant, $t(200) = 1.38$, $p = .170$, neither was the quadratic contrast, $t(200) = -0.57$, $p = .570$, but only the linear contrast was, $t(200) = 5.18$, $p < .001$.

In an exploratory manner, we also computed pairwise comparisons and Bayesian t-tests between the different word types, displayed in Table 1. These comparisons revealed that front-front and front-rear words were on an equally high level and rear-front and rear-rear words on an equally low level.[3]

2.3. Discussion

Experiment 1 provides first evidence against the articulation fluency account. On the one hand, front-rear (inward) words received higher articulation fluency judgments than rear-front (outward) words, thus paralleling differences in liking found by previous research, including Ingendahl and Vogel (2021). On the other hand, articulation fluency was as high for front-front as for front-rear words, despite a clear preference of front-rear to front-front words in the data of Ingendahl and Vogel (2021). Similarly, even though rear-front words were as fluent as rear-rear words in our study, rear-front words were liked less than rear-rear words in the data of Ingendahl and Vogel (2021). Thus, liking and articulation fluency align exclusively for pure inward and outward sequences, but not when considering the combination of inward/outward sequences of front-front and rear-rear stimuli. These findings speak against the articulation fluency account on the in-out effect.

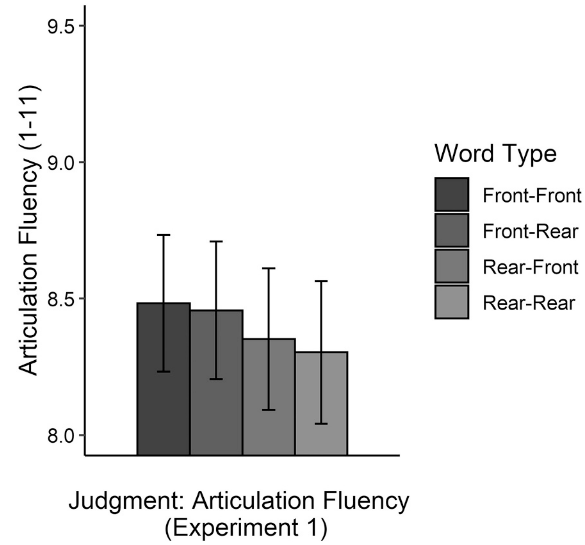

Fig. 1. Mean articulation fluency Judgments by word type in Experiment 1 ($N = 201$).
Note. Error bars depict 95% Confidence Intervals.

However, despite the parallel research design, it is still possible that some unknown factor (e.g., the time of data collection) led to the divergent results or that per chance fundamentally different stimuli were generated in the studies. To tackle this problem, we measured liking and articulation fluency in a between-participant design with fixed stimulus sets. Experiment 2 was preregistered on the OSF: https://doi.org/10.17605/OSF.IO/MY79C.

3. Experiment 2

3.1. Methods

3.1.1. Design & procedure

This experiment had the same repeated-measures factor word type (front-front vs. front-rear vs. rear-front vs. rear-rear). In addition, we varied between participants whether they should provide liking or articulation fluency judgments. Again, we recruited German native speakers on Prolific Academic to answer a short online survey. Participants received 0.53£ for a study of 4–5 min. The experimental task was identical to the one used in Experiment 1 (articulation fluency) or the one by Ingendahl and Vogel (2021; liking), except that we used 48 and not 96 words in this study.

3.1.2. Materials

In order to reduce the stimulus variation between participants we refrained from constructing individual word sets for each participant. Instead, only ten different sets of words were created and randomly assigned to participants. The words were generated according to the same procedure as in Experiment 1 but each consonant sequence was used only once and not twice (see Table S1 in Appendix A) producing 48 words per set.

[2] We had initially planned to exclude all participants with more than 64 identical responses (e.g., constantly answering “5”) as done by Ingendahl and Vogel (2021). However, his would have led to the exclusion of 37 participants. Apparently, articulation fluency judgments were more homogenous than liking judgments. Thus, we decided not to exclude any participant based on this criterion in any of the experiments

[3] In line with Ingendahl and Vogel (2021), we repeated the main analyses of both experiments with rigorous exclusion of all trials where words were homophone or identical (e.g., BATERI) to actual German words which revealed the same findings. This analysis is thus only provided in the OSF directory.

Table 1
Post-Hoc comparisons in Experiment 1 and 2.

	Experiment 1 (Articulation Fluency)				Experiment 2 (Articulation Fluency)				Experiment 2 (Liking)			
Comparison	*t*	*p*	d_z	BF_{10}	*t*	*p*	d_z	BF_{10}	*t*	*p*	d_z	BF_{10}
Front-front vs. Front-rear	0.81	0.418	0.06	0.11	−0.29	1.00	−0.03	0.09	−5.52	<0.001	−0.38	5324.66
Front-front vs. rear-front	3.89	<0.001	0.27	106.77	2.90	0.020	0.30	76.73	1.81	0.142	0.12	0.27
Front-front vs. rear-rear	4.68	<0.001	0.33	2202.03	2.04	0.126	0.20	2.06	−0.51	0.614	−0.03	0.10
Front-rear vs. rear-front	3.27	0.004	0.23	13.24	2.98	0.018	0.30	103.04	6.35	<0.001	0.42	38,426.89
Front-rear vs. rear-rear	4.71	<0.001	0.33	2484.23	2.74	0.026	0.25	14.28	4.18	<0.001	0.29	49.72
Rear-front vs. rear-rear	1.74	0.166	0.12	0.34	−0.35	1.00	−0.03	0.09	−2.42	0.049	−0.17	0.87

Note. P-values are corrected for multiple testing with the Holm-Bonferroni method. d_z = standardized difference scores. BF_{10} = Bayes Factor in a t-test conducted with the BayesFactor package with default priors (Morey & Rouder, 2018).

3.1.3. *Analytical procedure, power analysis, & participants*

We used a similar analytical approach as in Experiment 1 with polynomial contrasts, displayed in Table 2. Type of judgment was coded with a separate contrast (articulation fluency = 1, liking = −1). Additionally, we computed interaction contrasts for the three different polynomial contrasts. If liking and articulation fluency judgments aligned, one would expect that only the cubic main effect contrast is significant, and none of the interaction contrasts is significant. However, if indeed liking and articulation fluency judgments diverged as suggested by the comparison of Experiment 1 and the liking data of Ingendahl and Vogel (2021), one would expect that the cubic and the linear interaction contrasts are significant. Follow-up contrasts within each judgment condition should reveal a significant linear contrast for articulation fluency (as in Experiment 1), and a significant cubic contrast for liking judgments (as in Ingendahl & Vogel, 2021). As a rough approximation for this analysis, we used the within-between interaction interface in GPower (Faul et al., 2007) with two groups and four measures, $f = 0.1$, $\alpha = 0.05$, $(1\text{-}\beta) = 0.95$, $r = 0.5$, which led to a necessary sample size of $N = 216$. However, because this was only an approximation and the exact effect sizes in our contrast analysis were not known, we conservatively increased the sample size by 50%, leading to $N = 330$.

Again, we collected data from Prolific Academic. Our sample consisted of 330 Germans native speakers (158 male, 169 female, 3 diverse, $M_{\text{age}} = 29.34$, $SD_{\text{age}} = 9.76$, $\text{Range}_{\text{age}}$ [18; 69], 43% students). We checked whether participants mentioned or described the in-out effect when asked about the study purpose, which was not the case.

3.2. *Results*

The mean judgments of the four word types depending on the judgment type are depicted in Fig. 2. On articulation fluency front-front words and front-rear words did not differ and were both rated higher than rear-front words and rear-rear words, which also did not differ from each other – thus replicating Experiment 1. On liking, however, front-rear (inward) words were rated superior to all other word types, and rear-front (outward) words were rated inferior to all other word types, with front-front and rear-rear words in between – thus replicating Ingendahl and Vogel (2021).

The results of the corresponding contrast analysis are displayed in Table 2. Next to significant linear, and cubic main effect contrasts, the cubic interaction contrast was significant: For liking judgments, the cubic trend was stronger than for articulation fluency judgments. The linear interaction contrast, however, was not significant, even though the linear contrast only reached statistical significance in the articulation fluency condition.

As in Experiment 1, we computed pairwise comparisons and Bayesian *t*-tests, displayed in Table 1. Front-front and front-rear words were equally fluent whereas rear-front and rear-rear words were equally disfluent, as in Experiment 1. For liking, however, front-front words were clearly inferior to front-rear words. For the rear-front vs. rear-rear comparison only the frequentist but not the Bayesian test showed a difference between the word types (see Table 1).

3.3. *Discussion and further analyses*

Experiment 2 replicates the articulation fluency pattern of Experiment 1 and the liking pattern of Ingendahl and Vogel (2021): For both judgments, and in line with previous research, front-rear (inward) stimuli received higher ratings than rear-front (outward) stimuli. However, when extending the paradigm to front-front and rear-rear stimuli the pattern again diverged. These findings further speak against the articulation fluency account.

Interestingly, the extended design with front-front and rear-rear words also allows for a different interpretation of the in-out effect, namely as an effect actually reflecting two additive effects. The results of Experiment 2 and the study by Ingendahl and Vogel (2021) robustly show that people prefer words with the first consonant being articulated at the front (vs. the rear) of the mouth (see Fig. 2 and Footnote 4).[4] Also, they prefer words with the last consonant being articulated at the rear (vs. the front) of the mouth. The combination of both effects works in favor of inward words (first front and last rear) and leads to the highest liking, but it works against outward words (first rear and last front). Thus, the in-out effect can be conceptualized as an additive effect of two independent influences – the first and the last consonant.

We also observe in the articulation fluency data of our studies that words with a front consonant at first position are most fluent. However, the last consonant does not influence articulation fluency (see Figs. 1&2 and Footnote 4). Thus, articulation fluency might statistically explain a specific part of the in-out effect only, namely the effect of the first consonant. When looking at inward and outward words exclusively, one would observe only a partial mediation by articulation fluency as found by Bakhtiari et al. (2016). However, in our extended design one should

[4] We re-analyzed the articulation fluency judgments from Experiment 1 with a 2 (first consonant: front vs. rear) x 2 (last consonant: front vs. rear) within-subjects ANOVA. Only the main effect of the first consonant was significant, $F(1,200) = 28.08$, $p < .001$, with higher fluency judgments for words with front than rear consonants as the first consonant (see Figure 1). The main effect of the last consonant, $F(1, 200) = 2.62$, $p = .107$, and the interaction, $F(1, 200) = 0.32$, $p = .570$, were both not significant. We also re-analyzed the data of Experiment 2 with a 2 (first consonant: front vs. rear) x 2 (last consonant: front vs. rear) x 2 (judgment type: articulation fluency vs. liking) mixed ANOVA. In general, fluency judgments were higher than liking judgments, $F(1, 328) = 322.43$, $p < .001$. The main effect of the first consonant was significant, $F(1, 328) = 23.87$, $p < .001$, with higher means for front than rear consonants (see Figure 2). This main effect was moderated neither by the last consonant, $F(1, 328) = 2.38$, $p = .124$, nor by the type of judgment, $F(1, 328) = 0.03$, $p = .873$. The main effect of the last consonant was significant, $F(1, 328) = 12.96$, $p < .001$, but also the interaction of Last Consonant x Judgment Type, $F(1, 328) = 9.31$, $p = .002$. Only for liking judgments the last consonant had an effect with more positive ratings for words with a rear consonant compared to a front consonant, $t(328) = -4.70$, $p < .001$, but not for articulation fluency judgments, $t(328) = -0.39$, $p = .698$. The three-way interaction was not significant, $F(1, 328) = 2.79$, $p = .096$.

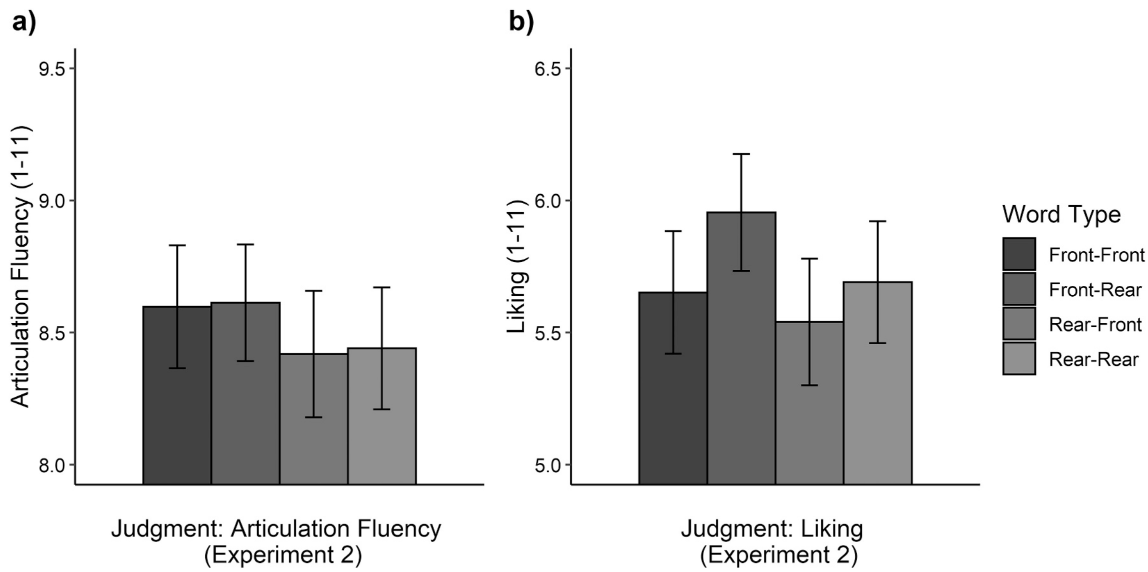

Fig. 2. Mean articulation fluency (a) and liking (b) judgments by word type in Experiment 2 ($N = 330$).
Note. Error bars depict 95% Confidence Intervals.

Table 2
Results from the preregistered contrast analysis in Experiment 2.

Contrast	Coding	*t*	*p*
Judgment (AF vs. Liking)	1,1,1,1,-1,-1,-1,-1	17.96	<0.001
Linear	3,1,-1,-3,3,1,-1,-3	2.78	0.006
Quadratic	1,-1,-1,1,1,-1,-1,1	−1.54	0.124
Cubic	−1,3,-3,1,-1,3,-3,1	5.92	<0.001
Judgment x Linear	3,1,-1,-3,-3,-1,1,3	1.06	0.290
Linear_{AF}	3,1,-1,-3,0,0,0,0	2.71	0.007
Linear_{Liking}	0,0,0,0,3,1,-1,-3	1.21	0.226
Judgment x Quadratic	1,-1,-1,1,-1,1,1,-1	1.67	0.096
Quadratic_{AF}	1,-1,-1,1,0,0,0,0	0.09	0.928
$\text{Quadratic}_{Liking}$	0,0,0,0,1,-1,-1,1	−2.27	0.024
Judgment x Cubic	−1,3,-3,1,1,-3,3,-1	−2.97	0.003
Cubic_{AF}	−1,3,-3,1,0,0,0,0	2.09	0.037
Cubic_{Liking}	0,0,0,0,-1,3,-3,1	6.29	<0.001

Note. AF = Articulation Fluency. All tests had df = 328.

see that articulation fluency fully mediates the effect of the first consonant but not the effect of the last consonant. To test this idea, we conducted two mediation analyses with lavaan (Rosseel, 2012) that were not preregistered. We aggregated all judgments on word level so that each word had a mean articulation fluency and liking score. With these aggregated judgments, we conducted mediation models with liking as outcome and articulation fluency as a mediator. Note that none of the models can test a causal effect of fluency because the relationship between fluency and liking is entirely correlative in this design (Fiedler, Schott, & Meiser, 2011) even though the effect of the word types on liking and fluency are induced experimentally. However, the effect at stake in this research area is an effect of word types on liking to be explained by fluency, thus justifying fluency as the mediator and liking as the outcome and not vice versa.

In our first mediation model (Fig. 3a), we only used inward and outward words and coded them with 1 and − 1. The results are visualized in Fig. 3. In line with the results of Bakhtiari et al. (2016), there was a partial mediation with a significant indirect effect, $b = 0.04$, $z = 2.00$, $p = .046$, but also a significant direct effect, $b = 0.14$, $z = 2.93$, $p = .003$, indicating that articulation fluency mediates only a part of the in-out effect.

In the second mediation model (Fig. 3b), we used all four word types and coded them with two contrasts: first consonant (1 = front, −1 = rear) and last consonant (1 = front, −1 = rear). For the effect of the first consonant, there was only an indirect effect, $b = 0.03$, $z = 2.46$, $p = .014$, but not a direct effect, $b = 0.05$, $z = 1.40$, $p = .163$. For the effect of the last consonant, there was no indirect effect, $b = -0.00$, $z = -0.31$, $p = .760$, but a direct effect, $b = -0.10$, $z = -2.88$, $p = .004$. Thus, the effect of the first consonant was fully mediated by articulation fluency, but the effect of the last consonant was not. Detailed results of both mediation models are provided in Appendix A.

4. General discussion

People prefer linguistic stimuli with an inward-oriented consonant sequence (front-rear; e.g., PATIKO) over those with an outward-oriented consonant sequence (rear-front; e.g., KATIPO), referred to as articulatory in-out effect (Topolinski et al., 2014). Previous research has postulated that this effect might be caused by a higher fluency of inward compared to outward articulation (Bakhtiari et al., 2016). In two high-powered experiments, we tested this explanation. For that purpose, we extended the established in-out paradigm to stimuli with mixed sequences, that is words that contain two front (e.g., PATIMO) and two rear (e.g., KATIGO) consonants. The articulation fluency data assessed in Experiment 1 do not align with previous data for liking judgments (Ingendahl & Vogel, 2021). This divergent pattern was confirmed by Experiment 2 that assessed both articulation fluency and liking in a between-participants design. Both experiments show that articulation fluency and liking judgments only align for front-rear (inward) and rear-front (outward) words. When extending the paradigm to front-front and rear-rear words, fluency and liking judgments differ. Overall, these findings offer valuable insights for our understanding of the in-out effect. Furthermore, they also bare interesting implications for future research on the in-out effect.

4.1. Theoretical implications

The first straightforward implication of our findings is that articulation fluency does not explain the in-out effect, in contrast to what was proposed by previous research (Bakhtiari et al., 2016; Körner et al., 2019). If articulation fluency alone caused the in-out effect, word types that differ in fluency should also differ in liking and word types with similar levels of fluency should show similar liking. Our results show that this is not the case. This does not mean, however, that word evaluation and articulation fluency are completely unrelated, as a plethora

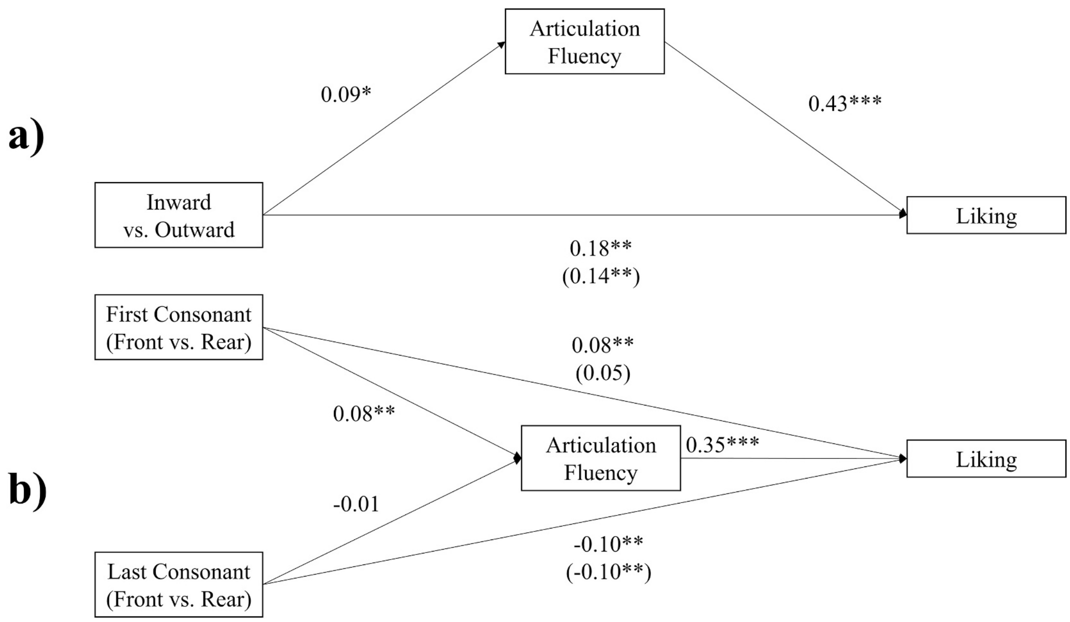

Fig. 3. Mediation analyses in Experiment 2 ($N = 330$).
Note. * $p < .05$ ** $p < .01$ *** $p < .001$.

of research attests to the effect of articulation fluency on stimulus liking (Alter & Oppenheimer, 2006; Laham et al., 2012). In fact, the mediation models of Experiment 2 also indicated a substantial correlation between articulation fluency and liking. However, the systematic difference in the liking of inward and outward words cannot be attributed to articulation fluency alone.

These findings also imply that future research must further theorize and investigate the source of the in-out effect. Originally, Topolinski et al. (2014) argued that inward articulation resembles food ingestion and outward articulation food expectoration, thus activating associated affective states (inward ➔ food ingestion ➔ positive, outward ➔ food expectoration ➔ negative). More recently, Maschmann, Körner, Boecker, and Topolinski (2020) suggested that people simply prefer front over rear consonants which has a stronger impact at word beginnings. However, both accounts were not supported by recent research (Ingendahl & Vogel, 2021; Körner & Rummer, 2021; Lindau & Topolinski, 2018a; Maschmann et al., 2020). Our present results call into question the remaining explanation, the articulation fluency account (Bakhtiari et al., 2016; Körner et al., 2019). Thus, the in-out effect remains an enigma. Yet, our experiments offer important implications for future research:

Even though our findings show that articulation fluency cannot be the sole explanation for the in-out effect, it still might be one piece in the puzzle. As discussed above, the extended paradigm with the orthogonal manipulation of the first and the last consonant offers a re-interpretation of the in-out effect, namely as an additive influence of an effect of the first and an effect of the last consonant: People like words with front consonants as the first, but also words with rear consonants as the last consonant. Both effects work in favor of inward, but against outward words, leading to the in-out effect. Our mediation analysis in Experiment 2 shows that articulation fluency fully mediates the influence of the first consonant, but not the influence of the last consonant. One should note that this mediation analysis does not prove a causal effect of articulation fluency (Fiedler et al., 2011). Still, the fact that words with a starting front consonant are more fluent fits to infants' language acquisition which usually starts with babbling front consonant syllables (e,g., \ba\; MacNeilage, Davis, & Matyear, 1997). Thus, future research might consider a multi-process theory where articulation fluency explains the preference for stimuli starting with front consonants and another (unknown) mechanism that explains the effect of the last consonant.

When doing so, however, in-out effect research must also move beyond the established paradigm that compares only inward and outward stimuli. As mentioned before, such narrow paradigms are not very diagnostic because many hypotheses are compatible with a difference between only two means (Fiedler, 2017). Our research shows that an extended paradigm that goes beyond these two word types can provide important insights into the underlying processes. Thus, a future theory on the in-out effect must explain not only inward-outward preferences, but also preferences among other types of stimuli.

4.2. Limitations

Our research also has several limitations. First, we restricted our studies to German participants to make sure that consonants have consistent articulation spots. As the in-out effect has also been found in other languages, future studies should investigate the effect of articulation fluency in other languages as well. Second, we used subjective measures of articulation fluency. Despite their prevalence in in-out effect research (Bakhtiari et al., 2016; Ingendahl, Schöne, et al., 2021; Körner et al., 2019; Lindau & Topolinski, 2018b) and the high validity of subjective fluency measures (Graf, Mayer, & Landwehr, 2018), future studies might consider using objective measures of articulation fluency as well, such as reading times.

Last, we used mixed inward/outward sequences (i.e., front-front and rear-rear words) to test the theoretical processes behind the in-out effect. One could argue that the scope of the in-out effect might be limited exclusively to *pure* inward/outward stimuli (i.e., front-rear and rear-front words). This would imply that the articulation fluency of mixed sequences is theoretically irrelevant for making causal assumptions on the processes behind the in-out effect. However, this argument would also imply that participants rely on articulation fluency exclusively when evaluating front-rear and rear-front stimuli, but they suddenly stop relying on fluency when evaluating a front-front or rear-rear word. As the latter stimuli differ merely in a single consonant from pure inward and outward stimuli, contain short inward/outward sequences as well, and were furthermore presented in random order in the same rating task as pure inward/outward stimuli, this is rather unlikely. Additionally, articulation fluency is a general mechanism that influences word evaluation beyond the in-out effect (e.g., Laham et al., 2012).

5. Conclusion

Despite differences between inward and outward words in both articulation fluency and liking, articulation fluency alone cannot explain the in-out effect. At the same time, our results show that in-out effect research benefits from going beyond the traditional inward/outward comparison when testing process explanations. In summary, the in-out effect proves to be a very robust yet ill-understood phenomenon.

Open practices

We report all measures, manipulations, and exclusions in this article. Experiment 2 was preregistered on the OSF: https://doi.org/10.17605/OSF.IO/MY79C.

All code, materials, and data are provided in this OSF directory: https://doi.org/10.17605/OSF.IO/AR3QC.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jesp.2021.104273.

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Case Report

Fluency in the in-out effect: The role of structural mere exposure effects

Moritz Ingendahl*, Tim Schöne, Michaela Wänke, Tobias Vogel

Dept. of Consumer & Economic Psychology, University of Mannheim, A5,6 B129, D-68159 Mannheim, Germany

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ABSTRACT

The articulatory in-out effect describes the preference for words with articulation moving inward compared to words with articulation moving outward. A promising explanation is that inward words are more fluent than outward words, but experimental evidence for such reasoning was offered only recently: By training selectively inward or outward words, fluency and consequentially liking was altered, leading to reversed or attenuated in-out effects when outward words were trained. However, it remains unclear whether such training procedures actually impact fluency of inward/outward movements, or whether they solely change the fluency of trained grammars. In two experiments (one preregistered, total $N = 501$), we show that training inward/outward words increases fluency and liking for trained grammar, but these effects do not generalize to in-out movements. The results show that training effects on liking reflect a structural mere-exposure effect rather than a change in liking for in-out motor movements. Findings are discussed regarding their implications for the fluency account, and the mental representation of inward and outward words.

The articulatory in-out effect (Topolinski, Maschmann, Pecher, & Winkielman, 2014) describes the preference for words with articulation moving inward compared to words with articulation moving outward. As an example, the word BODIKA requires to first form the B at the lips, then the D with the tip of the tongue, and lastly the K with the rear back of the tongue. Uttering the word therefore leads to an inward-directed sequence of oral motor-actions, compared to KODIBA with an outward-directed sequence of oral motor-actions. According to the in-out effect – and consistent with the empirical data – BODIKA, as an inward sequence, is liked more than KODIBA, an outward sequence.

This in-out effect can be shown consistently for words containing consonants from different articulation spots (Topolinski et al., 2014): In German, “b”, “p”, “m”, “w”, “f” are labial consonants generated in the front, “t”, “l”, “n”, “s”, “d” alveolar consonants generated in the middle, and “g”, “k”, “r” velar/uvular consonants generated in the rear of the mouth. Pseudowords with a front, then a middle, and then a rear consonant (e.g., BODIKA, MELIGO, FUTERI) therefore require an inward-directed sequence of oral motor-actions and are preferred to outward pseudowords that start with a rear, then a middle, and then a front consonant (e.g. KODIBA, GELIMO, RUTEFI). For the in-out effect, it does not matter which vowels are used within a word (Topolinski & Boecker, 2016).

Since it was first published, the in-out effect has proven a very robust social psychological phenomenon (cf. Topolinski, 2017): Besides English and German (Topolinski et al., 2014; Topolinski, Zürn, & Schneider, 2015), it has been shown in Portuguese (Godinho & Garrido, 2016), Ukrainian, and Turkish (Godinho, Garrido, & Horchak, 2019). The phenomenon has crucial consequences for person perception, that is people with inward (vs. outward) names are seen as warmer (Garrido, Godinho, & Semin, 2019; Godinho & Garrido, 2020) and more trustworthy (Silva & Topolinski, 2018). Yet, in spite of numerous empirical demonstrations of the effect, the theoretical explanation remains a matter of debate.

1.1. Theoretical background

Initially, the effect was explained by the similarity of oral food ingestion and articulation (Topolinski et al., 2014) – inward movements resemble the motorial pattern of food deglutition (swallowing), which is inherently positive, whereas outward movements resemble the motorial pattern of food expectoration (spitting), which is inherently negative. Thus, the in-out effect was assumed to occur because uttering inward-words (vs. outward words) involves the same motor activity as oral approach (vs. avoidance) behaviors. Although some predictions from this account were supported (e.g., Topolinski & Bakhtiari, 2016), recent research suggests that oral approach/avoidance associations are

* Corresponding author.
E-mail addresses: mingenda@mail.uni-mannheim.de (M. Ingendahl), tischoen@mail.uni-mannheim.de (T. Schöne), michaela.waenke@uni-mannheim.de (M. Wänke), tobias.vogel@uni-mannheim.de (T. Vogel).

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not responsible for the effect (Maschmann, Körner, Boecker, & Topolinski, 2020).

Recently, Bakhtiari, Körner, and Topolinski (2016) presented processing fluency as an alternative explanation. Corpus analyses for German and English show that inward sequences are more frequent in natural language (Bakhtiari et al., 2016). Thus, inward sequences should be more familiar and consequently be processed more fluently. Crucially, as proposed in the hedonic fluency model (R. Reber, Schwarz, & Winkielman, 2004), processing ease (or fluency) creates a positive affective state which leads to a more positive stimulus evaluation. Thus, the more fluent processing of inward words compared to outward words should lead to a preference for inward words.

Several findings support this fluency account: First, participants read inward words faster and rate them as easier to pronounce than outward words (Bakhtiari et al., 2016). Both findings indicate ease of processing. Second, the subjective articulation fluency partially mediates the in-out effect (Bakhtiari et al., 2016), corroborating that the in-out effect can be explained by fluency. However, such findings do not establish causality for the role of fluency.

Thus, recently, Körner, Bakhtiari, and Topolinski (2019) presented first experimental evidence for the fluency account by exposing participants to inward versus outward words: In a training phase, participants rehearsed either inward or outward words, thus manipulating the fluency of inward versus outward words. After this training phase, participants provided ratings of liking and articulation fluency of untrained inward/outward words. Consistent with the fluency account, a high exposure to inward words resulted in a robust in-out effect, whereas a high exposure to outward words attenuated (Körner et al., 2019, Exp. 1 & 4) or even reversed the in-out effect (Körner et al., 2019, Exp. 2 & 3).

Körner et al. (2019) took great care to control for alternative explanations: First, different words were used in the training and in the test phase. Second, the same letters were used to create inward- and outward words. Thus, the results cannot be explained by a mere exposure effect, neither at the word level (as test words were not trained), nor at the feature-level (i.e. because the same letters were used for both in- and outward words).

However, there is one procedural detail of Körner et al. (2019) that needs further consideration: Training and test words could still contain the same or similar consonant *sequences*. That is, if participants were exposed to an outward word like KODOBO in the training phase, it was possible that participants would later rate KADABA as a test word. This leaves open an alternative explanation for the results of Körner et al. (2019): It might be that training did not alter the fluency of inward/outward *movement*, but merely the fluency of specific *consonant sequences* (i.e., the sequence K-D-B; Gordon & Holyoak, 1983; Kinder, Shanks, Cock, & Tunney, 2003).

Findings in artificial grammar learning attest to the importance of specific letter sequences on stimulus liking (Reber, 1967). In this research, participants are usually exposed to word exemplars from an artificial language. This does not only increase the liking for the trained words, but also increases fluency and liking for new stimuli that follow the rules of the artificial grammar – a phenomenon also referred to as *structural mere exposure* effect (Folia & Petersson, 2014; Gordon & Holyoak, 1983; Kinder et al., 2003; Newell & Bright, 2001). As an example, if participants are exposed with outward words that contain the consonant sequence *G-L-B*, they will abstract a mental rule system that words with G in the beginning and B in the end are typical, whereas words constructed from the respective inward sequence (i.e., *B-L-G*) are not. As a consequence, other words that contain the consonant sequence *G-L-B* (or at least *G-B*) will be processed more fluently and thus evaluated more positively. The experiments of Körner et al. (2019) actually resemble such artificial grammar learning: Participants could have been exposed to the outward words GALABA or GULUBU in the training phase, and could have rated the inward word BOLOGO and the outward word GOLOBO in the test phase. According to structural mere exposure research, one would observe a preference for the outward word GOLOBO in this case.

Crucially, experimental research on artificial grammar learning shows that structural mere exposure effects are restricted to stimuli composed of the same letters or symbols as during familiarization (Newell & Bright, 2001; Zizak & Reber, 2004). This would imply that the training effect does not generalize to other inward/outward words built from a new letter set (e.g., MEDERE and REDEME), but is restricted to trained or very similar consonant sequences.

In conclusion, the results of Körner et al. (2019) are compatible with two different explanations: On the one hand, as the authors argue, training inward/outward words might have influenced the fluency of inward/outward movement. On the other hand, the training effect might actually reflect a structural mere exposure effect restricted to structurally similar inward/outward words. Thus, a critical test is needed here to disentangle both explanations.

1.2. The present research

In the present research, we conceptually replicate Körner et al. (2019) and use the same methods and materials, with one crucial exception: We use other training and test stimuli in order to differentiate between a) mere exposure effects (i.e. the identical words were trained), b) structural mere exposure effects, and c) training effects on actual inward/outward movement. That is, we expose participants to inward vs. outward words in a training phase, and assess liking (Experiment 1) and fluency (Experiment 2) of (a) the training words, (b) inward/outward words that were constructed from the same consonant sequences as the training words, and (c) inward/outward words that were constructed from completely new consonants. With this differentiation, we can expect the following results:

First, according to the classic mere exposure effect, rehearsing specific inward vs. outward words should alter fluency and liking (only) for those very words (word type a). Second, according to both the articulatory movement fluency and the structural mere exposure explanation, a higher exposure to specific inward vs. outward words should additionally alter fluency and liking for words that are constructed from the consonant sequences which the training words were based on (word type b). Third, and crucially, the two explanations differ in their predictions for words constructed from entirely new consonants (word type c): According to the original articulatory movement fluency explanation, rehearsing inward/outward words should make inward/outward movement more fluent, and therefore the manipulation must generalize to words constructed from new consonants that were not used in the training. Thus, when participants are exposed to outward words in the training procedure, the in-out effect must be attenuated or reversed for words constructed from new untrained consonants. According to the structural mere exposure explanation, only those words should receive higher fluency and liking judgments that were constructed from the rehearsed consonant sequences. Note, artificial grammar learning research shows that structural mere exposure effects are restricted to stimuli composed of the same letters or symbols as during familiarization (Newell & Bright, 2001; Zizak & Reber, 2004). Thus, rehearsing inward/outward words should only make other inward/outward words more fluent that are built from the same consonant sequences. For words built from new consonants, there should be no effect of the rehearsal, and the usual in-out effect should emerge.

Thus, we predict the following pattern of results: For the inward-training condition, inward words are judged as more fluent and more favorable, for all word types (a, b, and c) (H1). For the outward-training condition, both explanations predict that the in-out effect on fluency and on liking is attenuated/reversed for word types a and b (H2). Crucially, for word type c (new consonants), the original articulatory movement fluency explanation predicts that outward training attenuates/reverses the in-out effect (H3a). However, the concurring structural mere exposure explanation predicts that for word type c, inward words are still judged as more fluent and more favorable than outward words (H3b).

We tested these hypotheses with two experiments that only differed in the measured dependent variable. Experiment 1 assessed the effect on liking and was preregistered on the Open Science Framework (https://osf.io/6vzh2). Experiment 2 assessed perceived fluency. All measures, manipulations, and exclusions in the study are disclosed, as well as the method of determining the final sample size.

2. Method

2.1. Design

The experiments followed a 2(training: inward vs. outward) × 3(word type: identical vs. same consonants vs. new consonants) × 2(direction: inward vs. outward) mixed design, with training manipulated between and the other two factors manipulated within participants.

2.2. Procedure

Our questionnaire (including materials and instructions) is available on the OSF (https://osf.io/k5juy/). Since the original materials were publicly available, our experiments could follow the procedure of the original studies very closely. Our experiments were implemented in the online survey tool Sosci Survey (Leiner, 2019). Participants were told that they would begin with a short-term memory task (training phase) and afterwards would complete spontaneous evaluations of nonsense words (test phase). In the training phase, participants memorized either 144 inward or outward words in random order: For each trial, participants were instructed to read the word silently and memorize it. Upon a key response by the participant, the word disappeared and the participant was asked to type it in. As in the original study, a copy protection prevented copying and pasting the words, and capitalization was ignored. After the 144 trials, participants rated 36 inward and 36 outward words on an 11-point scale (with the labels 0 = *not at all* to 10 = *very much*) in random order. For Experiment 1 (liking), the question was “How much do you like this word?”, for Experiment 2 (fluency), the question was “How easy is it to pronounce this word?”. Afterwards, participants' sociodemographic data were assessed, participants were debriefed, thanked, and dismissed. Overall, the procedure was constructed to be as similar as possible to the original studies (Körner et al., 2019, Experiment 4a & 4b), with identical instructions, and only the following modifications:

First, participants were told how many trials each task had and how long they would take. Second, during the training as well as the test phase, participants could also see a counter of their progress in the specific task. Both deviations from the original study were included to limit the dropout during the long phases. Third, the training procedure consisted of 144 words instead of 120 or 130 words, as a consequence of our material generation.

2.3. Materials

The words were generated randomly and ad-hoc for each participant, from the same consonants as in Körner et al. (2019, Experiment 4). These were: “b”, “p”, “m”, “w”, “f” as front consonants; “t”, “l”, “n”, “s”, “d”, as middle consonants; “g”, “k”, “r” as rear consonants. Each of the three consonant sets was randomized anew for each participant, thus leading to different words for each participant. One exemplary word set is provided in Table 1.

First, the training words were generated by taking the first three consonants from the front set (e.g., b, p, m) and the middle set (e.g., t, l, n), and the first two consonants from the rear set (e.g., g, k). Using these consonants, all sequential combinations possible and in accordance with the respective participant's training condition were generated. As an example, in the inward training condition the sequences could be b-t-g, b-t-k, b-l-g, etc. (see Table 1). In the outward training condition the sequences were reversed, e.g. g-t-b, k-t-b, g-l-b, etc. This procedure resulted in 18 different consonant sequences for the training phase. For each sequence, four of the five vowels were randomly selected and placed after a consonant. In each word, we placed only one of these vowels, in order to be as similar as possible to Experiment 4 of Körner et al. (2019). Hence, the consonant sequence b-t-g, for example, could lead to the training words bataga, botogo, betege, bitigi (see Table 1 for further examples). Thus, there were four words per sequence, leading to 4 × 18 = 72 different words for the training phase. Each of these words was presented twice, as in Experiment 4 of Körner et al. (2019).

For the test phase, twelve of the eighteen consonant sequences from the training phase were selected. From each of these twelve trained sequences, we selected one explicitly trained word and also created its inward/outward counterpart by reversing the consonant order. For example, if bataga, botogo, betege, bitigi had been trained, bataga and gataba, or botogo and gotobo, etc. could be selected. Hence, there were 12 inward and 12 outward words for the identical-word condition. For the same-consonant words, we used the same 12 sequences, but inserted the last remaining vowel that had not been used for this specific sequence in the training phase. To return to the example above, butugu would be generated from the b-t-g sequence. Again, the articulatory counterpart was generated by reversing the consonant order (e.g., gutubu), also leading to 12 inward and 12 outward words. For the new-consonant words, there were two front (e.g. w, f), two middle (e.g., s, d), and one rear (e.g., r) consonants left, resulting in four different consonant sequences. Each of them was filled with three random vowels, e.g. wasara, wosoro, wesere. Again, the articulatory counterpart was generated by reversing the consonant order, leading to another 12

Table 1
Sample stimuli for a single participant resulting from the material generation.

Phase	Direction of trained words	
	Inward	Outward
Training	bataga, betege, bitigi, botogo, beteke, butuku, bataka, bitiki, balaga, … boloko, … bunugu, … … meneke, monoko, munuki, miniki	gataba, getebe, gitibi, gotobo, ketebe, kutubu, kataba, kitibi, galaba, … kolobo, … gunubu, … … keneme, konomo, kunumi, kinimi

Phase	Direction of rated words					
	Inward			Outward		
	Identical	Same consonants	New consonants	Identical	Same consonants	New consonants
Test	bataga	butugu	wasara	gataba	gutubu	rasawa
	beteke	botoko	wosoro	ketebe	kotobo	rosowo
	balaga	bologo	wesere	galaba	golobo	resewe
	boloko	balaka	wuduru	kolobo	kalaba	ruduwu
	bunugu	bonogo	wadara	gunubu	gonobo	radawa
	…	…	…	…	…	…
	meneke	manaka	fidiri	keneme	kanama	ridifi

Note. Words were generated randomly and ad-hoc for each participant. Thus, the word material was different for each participant. Participants in the training inward condition were exposed only to the training inward words in the training phase, participants in the training outward condition were exposed only to the training outward words in the training phase. The rated words were used in both conditions.

inward and 12 outward words.

2.4. Power analysis

We calculated a-priori power analyses with G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007). As a conservative approximation for Experiment 1, we sought to replicate the in-out effect within each factorial cell of our design for small effect sizes. Hence, we used paired *t*-tests[1] with $\alpha = 0.05$, $\beta = 0.8$, $d_z = 0.2$, one-tailed, as input criteria, leading to a necessary sample size of 156 each for the training inward and training outward condition. Hence, we aimed at recruiting a minimum of 320 participants. Following the preregistration, we collected data until $N = 320$, after which we kept the study online for another week. Assuming fluency is the mediator in the in-out effect, we expected slightly stronger effect sizes for Experiment 2. We therefore used $\alpha = 0.05$, $\beta = 0.8$, $d_z = 0.3$, one-tailed, as input criteria, leading to a necessary sample size of 71 in each training condition. Hence, we aimed at recruiting a minimum of 145 participants.

2.5. Participants

For Experiment 1, we recruited a total amount of 353 participants (283 female, 70 male; $M_{age} = 24.43$, $SD_{age} = 8.13$) via personal contacts, mailing lists, social media, and other channels. Students from a German university could receive partial course credits. For the other participants, a raffle for 3 × 20€ Amazon vouchers was used as incentive. Participants were mostly native German speakers (95.5%) and students (85.3%). Following the preregistration protocol, we excluded two participants that mentioned the in-out effect when asked about the study purpose, leading to a final sample of 351 participants.

For Experiment 2, 148 participants (72 female, 76 male; $M_{age} = 27.74$, $SD_{age} = 7.95$) were recruited from Prolific Academic and paid with approximately 2.78$ for a 20-min study. Again, they were mostly native German speakers (96.6%), with half of them (50.7%) being students.

2.6. Pilot study

As our procedure requires that only a subset of consonants is used in the training phase, test words in each condition became more homogeneous than test words in previous studies which had used all possible combinations. We therefore conducted a pilot study (after preregistration, but before data collection) to test if the new word set is able to produce the necessary baseline in-out effect. 150 German citizens (59 female, 91 male; $M_{age} = 31.09$, $SD_{age} = 10.06$, 147 native speakers) were recruited via Prolific Academic for a series of studies. The pilot study asked participants for an evaluation of the 2 × 12 new-consonant words without a training session beforehand. We used the same materials and instructions as in the main studies. A paired samples *t*-test revealed a higher preference for inward words, $M = 5.35$, $SD = 1.52$, compared to outward words, $M = 5.17$, $SD = 1.56$, $t(149) = 2.21$, $p = .029$, $d_z = 0.18$, thus replicating the in-out effect and also justifying our a priori effect size assumptions.

3. Results

3.1. Main results: liking (Experiment 1)

The results are visualized in Fig. 1. Following the analysis plan in the preregistration, we aggregated the mean evaluations for each factorial cell within participants to conduct a mixed ANOVA with the afex package in R (Singmann, Bolker, Westfall, Aust, & Ben-Shachar, 2020). Due to violations of sphericity, we report Greenhouse-Geisser corrected values for the word type main effect and the Word Type × Direction interaction. As a robustness check, all analyses were also replicated with multilevel models, using the lme4 package in R (Bates et al., 2019) and the highest converging model regarding intercepts and slopes (Barr, Levy, Scheepers, & Tily, 2013). The results did not change and can be retrieved from the OSF directory.

Critical for our hypotheses H1 and H2, we observed a Training × Direction interaction, $F(1, 349) = 119.09$, $p < .001$, $\eta^2_G = 0.026$, and a Training × Word Type × Direction interaction for H3b, $F(1.53, 533.63) = 47.30$, $p < .001$, $\eta^2_G = 0.010$. As can be seen in Fig. 1, there was a preference for inward over outward words in the inward-training condition. In the outward-training condition, the pattern reversed, resembling a preference for outward compared to inward words. Crucially, this effect depended on the word type: Whereas both identical words and same-consonant words were affected by the training manipulation, for words with new consonants the regular in-out effect emerged, independently of training (see Fig. 1). Additionally, there was a main effect of word type, $F(1.24, 431.61) = 63.50$, $p < .001$, $\eta^2_G = 0.040$, indicating higher liking for identical- and same-consonant words compared to new-consonant words. Also, there was a significant main effect of direction, $F(1, 349) = 10.90$, $p = .001$, $\eta^2_G = 0.002$, with more liking for inward than for outward words. All other terms remained insignificant, $Fs < 2.47$, $ps > 0.109$. Following the preregistration protocol, we also compared inward and outward words within each factorial cell with paired *t*-tests, reported in Table 2. All comparisons were significant, also when controlling for alpha inflation via the Holm-Bonferroni method. In sum, these results provide clear support for H1, H2, and H3b. The data as well as the analysis script are provided in the OSF directory.[2]

3.2. Main results: fluency (Experiment 2)

We used the same analytical approach as for the liking ratings. In a nutshell, the results were similar to the liking ratings (Fig. 2, Table 3), providing additional support for H1, H2, and H3b. In the mixed ANOVA, we observed a Training x Direction interaction, $F(1, 146) = 55.38$, $p < .001$, $\eta^2_G = 0.006$, and a Training x Word Type x Direction interaction, $F(1.72, 251.28) = 15.37$, $p < .001$, $\eta^2_G = 0.002$. Additionally, there was a significant main effect of word type, $F(1.29, 188.06) = 49.79$, $p < .001$, $\eta^2_G = 0.027$, and a main effect of direction, $F(1, 146) = 15.85$, $p < .001$, $\eta^2_{pt} = 0.006$. All other terms remained insignificant, $Fs < 2.20$, $ps > 0.121$. Again, paired *t*-tests were computed within each factorial cell, reported in Table 3. All comparisons were significant, also when correcting for multiple testing with the Holm-Bonferroni method.

4. General discussion

The articulatory in-out effect describes the preference for words involving an inward compared to an outward articulatory movement. A recent theory has explained the effect by different levels of fluency for inward versus outward words (Bakhtiari et al., 2016; Körner et al., 2019). However, experimental evidence for such reasoning was offered only recently, by exposing participants selectively to inward or outward

[1] A power analysis for a between-within interaction with the same input criteria and f = 0.1 (for Experiment 1) and f = 0.15 (for Experiment 2) suggested less participants, namely $N = 200$ and $N = 90$. Because a significant interaction also required follow-up paired samples *t*-tests, we used the more conservative sample size determination from the paired samples *t*-tests.

[2] Additionally, our ad-hoc stimulus generation produced some inward/outward words that were identical or somewhat similar to existing German words. In order to control for this, we reran all main analyses with a restricted stimulus set where all existing words (e.g., "BELEGE") or phonologically similar words (e.g. "WASAGA" similar to "Wahrsager") were excluded. None of the results changed. These analyses are also provided in the OSF directory.

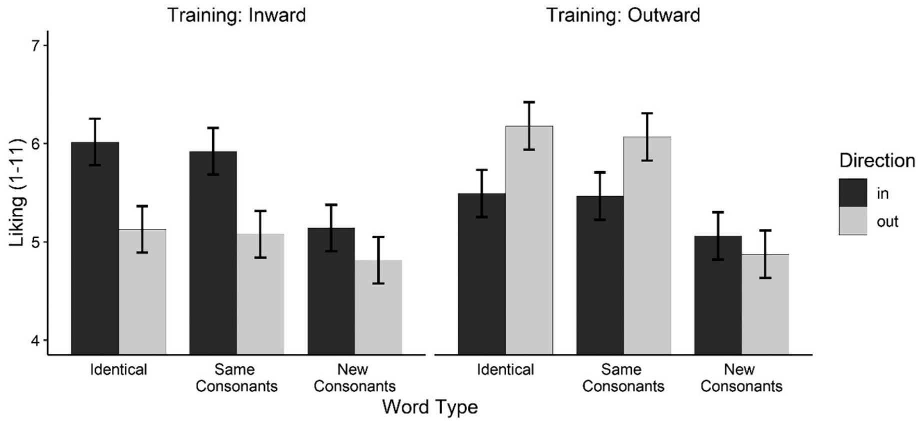

Fig. 1. Mean liking ratings in Experiment 1.
Note. Error bars represent 95% confidence intervals.

Table 2
t-Tests comparing the mean liking of inward and outward words for each factorial cell in Experiment 1.

Training	Word type	Direction		*df*	*t*	*p*	d_z
		Inward	Outward				
Inward	Identical	6.02 (1.74)	5.13 (1.61)	183	8.95	< 0.001	0.66
	Same consonants	5.93 (1.67)	5.08 (1.52)	183	8.89	< 0.001	0.66
	New consonants	5.14 (1.76)	4.82 (1.63)	183	4.40	< 0.001	0.32
Outward	Identical	5.50 (1.44)	6.18 (1.57)	166	−6.01	< 0.001	−0.47
	Same consonants	5.47 (1.35)	6.07 (1.52)	166	−5.60	< 0.001	−0.43
	New consonants	5.06 (1.74)	4.88 (1.66)	166	2.41	0.017	0.19

Note. All means were based on a 11-point rating scale. Standard deviations appear in parentheses. *p*-Values are corrected for multiple testing with the Holm-Bonferroni method.

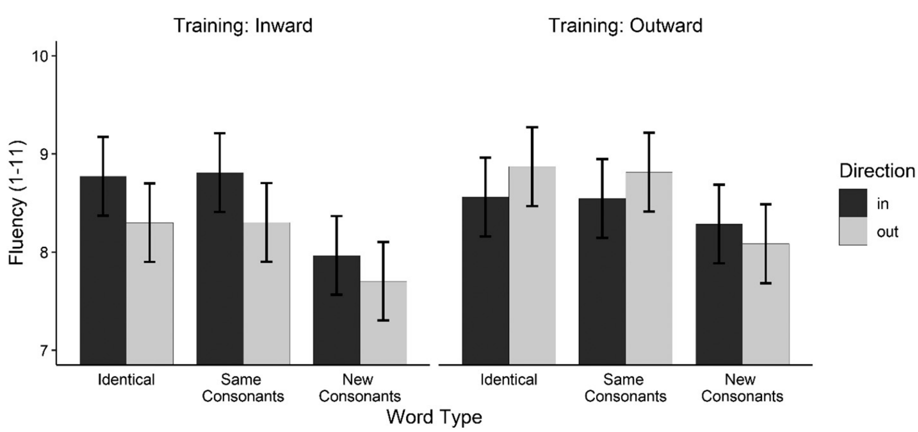

Fig. 2. Mean fluency ratings in Experiment 2.
Note. Error bars represent 95% confidence intervals.

Table 3
t-Tests comparing the mean fluency of inward and outward words for each factorial cell in Experiment 2.

Training	Word type	Direction		*df*	*t*	*p*	d_z
		Inward	Outward				
Inward	Identical	8.77 (1.63)	8.30 (1.81)	74	6.03	< 0.001	0.70
	Same consonants	8.81 (1.52)	8.30 (1.76)	74	7.34	< 0.001	0.85
	New consonants	7.97 (1.87)	7.70 (1.86)	74	2.92	0.009	0.34
Outward	Identical	8.56 (1.79)	8.87 (1.70)	72	−4.17	< 0.001	−0.49
	Same consonants	8.55 (1.78)	8.82 (1.61)	72	−3.40	0.003	−0.40
	New consonants	8.29 (1.76)	8.09 (1.85)	72	2.36	0.021	0.28

Note. All means were based on a 11-point rating scale. Standard deviations appear in parentheses. *p*-Values are corrected for multiple testing with the Holm-Bonferroni method.

words and measuring liking and fluency afterwards (Körner et al., 2019). In this paper, we argued that previous results are ambiguous as to whether they actually reflect training effects on articulatory movements, or merely structural mere exposure effects due to artificial grammar learning. We addressed this issue in two experiments, one of which was preregistered. We first exposed participants to a subset of inward/outward consonant sequences and then measured liking and subjective fluency of inward/outward words composed from these consonant sequences, and of inward/outward words constructed from new consonants. Based on the original articulatory movement fluency explanation, exposure to specific inward/outward consonant sequences should have increased the fluency of inward/outward movement in general, and therefore also fluency and liking of inward/outward words constructed from new consonants. Based on a structural mere exposure explanation, exposure to specific consonant sequences should have fostered processing ease and increased liking exclusively for these specific consonant sequences, without a generalization to inward/outward sequences from new consonants.

In both experiments, we observed the same pattern: Whereas our manipulation affected words from the training phase, and new words built from the trained consonant sequences, test words built from new consonants remained unaffected.[3] For those words, we only observed a reliable in-out effect but neither liking nor fluency judgments were affected by the prior familiarization with other inward/outward consonant sequences.

These results clearly demonstrate that training does not alter articulation fluency of inward/outward words as suggested by Körner et al. (2019). Instead, training affects only those specific consonant sequences that were trained. These results clearly favor a structural mere exposure explanation – exposure to specific consonant sequences induces the learning of a grammar and fosters the processing ease (and also liking) for these specific consonant sequences, without a generalization to other inward/outward sequences. As such, our findings are also perfectly in line with research on artificial grammar learning and structural mere exposure effects (Gordon & Holyoak, 1983; Newell & Bright, 2001; Zizak & Reber, 2004). In fact, the effect for trained consonants was as large as the effect of training identical words, which speaks again to the relevance of trained grammar in mere exposure effects. Our results bear interesting implications which are discussed in the next section.

4.1. Theoretical implications and future directions

First, our findings have theoretical implications for the mental representation of the proposed concepts (i.e. inward words and outward words). As the fluency of one subset did not impact the fluency of all other subsets of inward/outward words, we conclude that different words within each category (e.g., different inward words) do not share a common mental representation. Thus, the processes underlying the in-out effect operate covertly and without any explicit or implicit categorization of a word as inward or outward. Furthermore, our studies show that people can have positive attitudes towards some and negative attitudes towards other consonant sequences, even though they share a similar articulatory movement.

Second, our findings clearly show that generalized articulation fluency due to a higher exposure to inward consonant sequences cannot explain the in-out effect. Instead, they attest to the power of structural fluency on reversing the in-out effect.

Though the exact role of fluency in the “natural” in-out effect remains an open question, our studies may extend previous theorizing on fluency and the in-out effect. One way to make sense of the present finding is that the “natural” in-out effect is not due to fluency at all and a strong fluency manipulation simply overrode the effect in the relevant training conditions. However, we still observed a fluency advantage of inward words for new- consonant words. Also, as mentioned in the introduction, previous research already provided empirical evidence for a mediating role of fluency (Bakhtiari et al., 2016). Thus, the idea of a general inward fluency advantage needs to be integrated with the structural fluency results of our experiments.

One possibility was already discussed by Bakhtiari et al. (2016): a mere biomechanical advantage of inward words implying that inward articulation movement is per se more fluent, and not because it is executed more frequently. From this perspective, one should expect a mediation by articulation fluency: inward words are motorically more fluent than outward words and therefore liked better. In light of the present findings, however, one might speculate that biomechanics also have an indirect effect by shaping the development of our language (Davis & MacNeilage, 2000; MacNeilage & Davis, 2000): The development of language should have favored consonant sequences that are easy to articulate. This would result in different frequencies of (and thus different exposure to) inward/outward sequences in natural language, as found by Bakhtiari et al. (2016). These different exposure levels to inward/outward sequences, however, are not the cause but the result of a general articulation fluency of inward movements. Still, exposure to frequent inward consonant sequences should additionally increase their structural fluency. Thus, the in-out effect should vary in strength depending on the frequency of the specific consonant sequence in natural language. In line with this notion, previous investigations indeed found some variation between different in/out words in stimulus-level analyses (Topolinski et al., 2014; Topolinski & Boecker, 2016).

Future research might therefore profit from more fine-grained corpus analyses to directly assess the frequency of specific consonant sequences in different languages. This provides the opportunity to examine the effect of “natural” grammar learning on the in-out effect. Also, if there is a consistent dominance of inward sequences over outward sequences in a variety of languages, this would speak for an indirect effect of biomechanics on language development. Moreover, differences in the in-out effect between languages that vary in their inward/outward frequency could show that the effect is indeed partially composed of structural fluency.

Lastly, our results match with a new theoretical account on the in-out effect, namely that it is grounded in a preference for front over rear consonants which is stronger if the consonants are at the beginning of a word (Maschmann et al., 2020). This account suggests that the in-out effect is only a side phenomenon originated in consonant preferences: Inward words start with a front consonant and end with a rear consonant, but outward words start with a rear consonant and end with a front consonant. Because the preference for front consonants is more pronounced at the beginning of a word, inward words (front-rear) are preferred to outward words (rear-front; Maschmann et al., 2020). From this account and consistent with our findings, one would assume no generalization of fluency from specific inward/outward sequences to inward/outward sequences from new consonants. Also consistent with our findings, this consonant preference account does not require any

[3] As can be seen in Table 2, the in-out effect of the new-consonant words was descriptively larger in the inward training condition, $d_z = 0.32$, than in the outward training condition, $d_z = 0.19$. One might conjecture that this indeed resembles a modulation of the in-out effect for the new-consonant words by the training procedure. Therefore, we tested this difference for significance by computing a mixed ANOVA, but only with the new-consonant words. For the liking data, there was only a main effect of direction, $F(1, 349) = 22.88$, $p < .001$, $\eta^2_G = 0.006$, but no interaction between direction and training, $F(1, 349) = 1.70$, $p = .193$, $\eta^2_G < 0.001$. Also note that the effect size of the new-consonant words in the outward training condition, $d_z = 0.19$, was virtually the same as in the pilot study, $d_z = 0.18$, where no words had been trained at all. For the fluency data, there was also only a main effect of direction, $F(1, 146) = 13.98$, $p < .001$, $\eta^2_G = 0.004$, and no interaction between direction and training either, $F(1, 146) = 0.25$, $p = .616$, $\eta^2_G < 0.001$. The insignificant interactions were also replicated in a Bayesian mixed ANOVA with the software JASP with default settings, suggesting strong evidence for the absence of an interaction for liking, $BF_{01} = 17.27$, and fluency, $BF_{01} = 7.72$.

explicit or implicit shared representation of words as inward or outward, as the articulatory movement is not expected to be responsible for the effect. Furthermore, as Maschmann et al. (2020) discuss, the preference for front over rear consonants is unlikely to come from different frequencies of front and rear consonants, as the latter are actually more common in natural language. Thus, natural grammar learning is unlikely to be responsible for the preference for front consonants. This strengthens our argument that natural frequencies of inward and outward sequences are not necessarily responsible for preferences for inward over outward words. Finally, and similar to our suggestions, Maschmann et al. (2020) discuss that biomechanical processes could play a role, as front consonants are universally the first consonants infants articulate (Oller, Wieman, Doyle, & Ross, 1976) which suggests that they are motorically more fluent.

4.2. Conclusion

The articulatory in-out effect has previously been explained by processing fluency. The present findings challenge the idea of a general articulation fluency advantage for inward words caused by different exposure to inward/outward words. Moreover, they challenge the idea of a shared mental representation of inward and outward words. Instead, the findings show that people hold more sophisticated representations at the level of specific consonant sequences. Thus, fluency can differ between different in-out words, leading to more specific word preferences.

4.3. Open practices

Experiment 1 was preregistered on the OSF (https://osf.io/6vzh2). All materials, data, and analyses in this manuscript are provided on the OSF (https://osf.io/k5juy/).

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Trends in Cognitive Sciences

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The articulatory in-out effect: replicable, but inexplicable

Moritz Ingendahl, [1,4,*,@]
Tobias Vogel, [2] and
Sascha Topolinski[3]

People prefer inward over outward articulation dynamics, a phenomenon referred to as the articulatory in-out effect. It is empirically robust and generalizes across languages, settings, and stimuli. However, the theoretical explanation of the effect is still a matter of lively debate and in need of novel research directions.

Which one of the following fictional words do you like more? MADIKO or KADIMO? We would predict that you prefer MADIKO – like most individuals [1]. But why is MADIKO more positive to us than KADIMO when both words are highly similar and even consist of the same letters? The answer lies in the articulation dynamics of the two words (Box 1). MADIKO is a word with an inward articulation dynamic, whereas KADIMO contains an outward articulation dynamic. A vast amount of recent research shows that individuals prefer inward over outward articulation dynamics, a phenomenon usually referred to as the (articulatory) in-out effect [1]. This in-out effect has been shown to affect various judgments and decisions. For instance, people like fictional nonsense words, politician surnames, and companies with an inward dynamic more than those with an outward dynamic [1]. Ebay sellers with inward names are judged as more trustworthy and eventually preferred as transaction partners [2]. Other studies show that inward names can even increase the consumption and tastiness of dishes [3].

What may first sound like a catchy phenomenon that does well in textbooks but not so well in replication studies has proven to be a robust phenomenon in current cognitive psychology. And even though the in-out effect is usually of modest size, very few boundary conditions seem to exist for it.

A robust and replicable phenomenon

So far, the in-out effect has been shown across languages such as English [1], French [3], German [4], Portuguese [5], among others, speaking for a universal and against a language-specific underlying process. Furthermore, it is not even necessary that the articulation dynamics be motorically executed, as the in-out effect also occurs under silent reading [1], when merely listening to a speaker [6], and even when oral motor movements are suppressed [7]. Correspondingly, the stimuli themselves do not even need to be pronounceable words, with mere consonant sequences (e.g., MD vs DM) already sufficing [6]. These findings speak against the necessity of an overt or even a covert verbal or muscular production of an articulation dynamic.

However, a minimum level of phonological activation does seem to be required. The in-out effect emerges for presentation times as fast as, but not below 50 ms [8]. Similar thresholds have been identified for phonological encoding, suggesting that the effect is not due to mere orthographic or perceptual processing. Also, the effect cannot be found among aphasia patients with deficits in brain areas that translate the sight of a letter into subvocalizations [1], implying that the effect is based on language processing and not on mere visual processing. Apart from these few confinements, however, the in-out effect is still an enigma.

An inexplicable phenomenon?

Whereas empirical robustness is usually desirable from the perspective of replicability, sometimes it bears negative consequences on a theoretical level. As the effect is insensitive to different contexts and experimental manipulations, one can hardly identify the underlying processes. This problem of too much replicability is rare in psychology, but it has gutted all previous attempts to explain the in-out effect.

The initial theory was that articulation dynamics contain motor patterns similar to food ingestion: Inward articulation resembles food ingestion such as swallowing, whereas outward articulation resembles food expectoration such as spitting [1]. Food ingestion is positive but food expectoration is negative. Thus, inward/outward stimuli were expected to elicit covert motor simulations that in turn activate the associated affective states and thereby influence preference. Such an eating-related explanation would predict the following. (i) Articulation dynamics should interact with the edibility and palatableness of a (food) object. For edible and palatable objects, the in-out effect should be stronger than for inedible and unpalatable objects (such as a toxic chemical). This has indeed been shown in some, but not in all studies [9]. (ii) The in-out effect should disappear when covert motor simulations are prevented. However, the effect resists subvocalization suppression (e.g., via concurrent whispering [7]). (iii) The in-out effect should interact with food-related physical states of the subject. For example, food deprivation should make food ingestion more appealing whereas disgust inductions should make food ingestion less appealing [10]. However, neither food deprivation nor disgust influence the in-out effect [10].

A subsequent theory posited that inward articulation is simply more fluent [11]. Fluency is considered to be an inherently positive experience; thus inward dynamics should be more positive as well. Such an articulation fluency account would predict the following. (i) Inward words should be easier to articulate than outward words and articulation

Box 1. What are articulation dynamics?

Whenever we articulate language, the consonants we form can be arranged on a front-to-rear axis [1]. As an example for English phonation, uttering the fictional word MADIKO requires to first form the bilabial [m] by pressing the lips together, then the alveolar [d] by touching the front palate with the tip of the tongue, and lastly the velar [k] by pressing the rear back of the tongue against the rear palate (Figure I). These articulation spots form a sequence from the front to the rear of the mouth – an inward dynamic. For the fictional word KADIMO, however, the order of the consonantal articulation spots is reversed, thus constituting an outward dynamic. Crucially, the two words consist of the same phonemes, only their articulation dynamics differ. Depending on the specific language, different consonant letters have well-demarcated articulation spots and can thus be used to generate inward or outward dynamics. For example, P and B are also consistently formed at the front of the mouth in English language, whereas R and G are consistently formed at the rear of the mouth only in other languages (e.g., German).

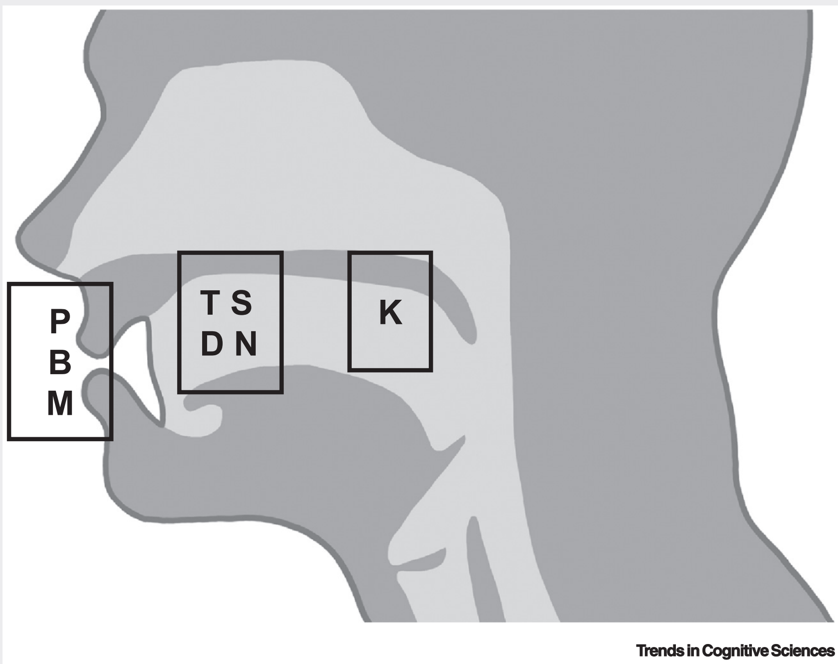

Figure I. Different consonant letters mapped to different articulation spots along a back-to-front axis, taken from English phonation.

fluency should mediate effects of inward versus outward words on other dependent variables (e.g., word liking). Inward words are indeed easier to articulate [11,12]. However, articulation fluency only partially mediates the in-out effect for word liking [11]. (ii) The in-out effect should increase in contexts where fluency effects also increase. For instance, fluency effects benefit from the experience of different levels of processing ease and are thus more pronounced in within-subjects designs than between-subjects designs [5]. However, this does not seem to be the case for the in-out effect [3,5]. (iii) Experimental articulation fluency trainings should modulate the in-out effect. For instance, articulating words with the outward sequence K–D–M (e.g., KADIMO) should make outward articulation more fluent and thus attenuate the in-out effect. Empirically, however, training articulation fluency of a specific inward/outward sequence benefits only the same sequence, but not inward/outward dynamics in general [12].

Another recent theory is that people do not prefer inward dynamics *per se*, but only consonants produced at the front of the mouth (e.g., [m], [p], [b]) [10]. If this preference for front consonants has the strongest impact on judgments when a consonant is at the beginning of the articulation sequence it would create the epiphenomenon that an inward dynamic (e.g., MADIKO) appears to be more positive than an outward dynamic (e.g., KADIMO). However, recent findings show that inward front–middle–rear words (e.g., MADIKO) are also preferred to front–middle–front words (e.g., MADIPO), speaking against mere front-consonant preferences as an explanation for the in-out effect [4].

Concluding remarks and future perspectives

To conclude, the past years of research on the in-out effect have revealed two core insights: (i) articulation dynamics exert a robust and apparently universal influence on human judgments and decision making; and (ii) all attempts to explain the phenomenon have failed eventually.

It seems that in-out effect research has currently reached a conceptual impasse. Thus, which steps could be taken next? In the following, we briefly discuss some potential directions for future investigations that might help identifying the processes underlying the in-out effect.

First, the effect has been investigated mostly in Indo-European languages with Latin script. Although single studies indicate that the effect is also present in other language families (i.e., Turkic) and scripts (i.e., Cyrillic), replications in more distant families and writing systems (such as in Chinese languages) might reveal the boundaries of the phenomenon. Second, initial corpus analyses indicate that front consonants are more prevalent at the word onset, but rear consonants more prevalent at word endings [11]. However, sophisticated corpus analyses assessing the prevalence of inward and outward sequences in natural languages are missing. Third, the occurrence of the in-out effect across languages speaks for an early development in the course of life. However, at which developmental stage does the effect occur? Studies with children and possibly even individuals who are deaf from birth may inform us which developments (e.g., phoneme production) are required for the effect to occur. Fourth, studies on aphasic patients point to the pertinent processing in specific brain regions [1]. However, the neurological understanding of the in-out effect is still poor. Neuroimaging and neurostimulation is advocated to study regions associated with language processing (e.g., temporal lobe) and motor-related processes (e.g., motor cortex). Finally, the in-out effect cannot be explained by a preference for single phonemes, but is an effect of the joint occurrence of multiple phonemes in the same articulation sequence. Yet, the in-out effect may reflect a rather specific effect of a broader class of phoneme combination effects (i.e., the dynamics of phoneme sequences) on preference formation.

With these potential directions for future investigations, we also want to encourage other researchers to join us in the search for the underlying mechanisms. We believe that the in-out effect is a promising research area that can further our understanding of how humans process language, develop preferences, and arrive at judgments and decisions.

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Declaration of interests

No interests are declared.

[1]Department of Psychology, University of Mannheim, DE-61859 Mannheim, Germany
[2]Department of Social Sciences, Darmstadt University of Applied Sciences, DE-64295 Darmstadt, Germany
[3]Department of Psychology, University of Cologne, DE-50931 Köln, Germany
[4]https://moritzingendahl.com

*Correspondence:
mingenda@mail.uni-mannheim.de (M. Ingendahl).
[@]Twitter: @moritzingendahl (M. Ingendahl).
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