The Effects of Inward versus Outward Articulation Dynamics on Familiarity

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Berit Lindau

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Erstgutachter: Jun.-Prof. Dr. Sascha Topolinski

Zweitgutachter: Prof. Dr. Christian Unkelbach

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Summary

In recognition research, the term familiarity is used to describe the diffuse feeling of having previously encountered a stimulus without being able to recall the actual situation and circumstances of this encounter (e.g., Jacoby, 1991; Mandler, 1980). In that sense, familiarity can also be illusory, which means the feeling can be triggered by other factors such as certain features of the stimulus even when the stimulus was actually never presented before. Studies have shown that the positivity of a stimulus, for example, can evoke the perception that the stimulus is familiar (e.g., Monin, 2003), and that even superficial manipulations such as increased perceptual fluency elicit the same effect (e.g., Whittlesea, 1993).

Recent research has discovered a new feature of such a rather superficial nature in word stimuli, namely the articulatory pattern of a word that is elicited by the order of its consonants (Topolinski, Maschmann, Pecher, & Winkielman, 2014). Specifically, there are consonants that are articulated more to the front of the mouth, for example at the lips, while other consonants are articulated further to the back, for example at the soft palate or in the throat. Pronouncing these consonants in the direction front-to-back or back-to-front can create oral movements that either wander inwards or outwards in the mouth, respectively. Topolinski et al. (2014) found that pseudo-words following such an inward consonantal direction were generally liked more than pseudo-words following an outward pattern. They explained this effect by associations between inward articulatory movements and positive, approach related oral movements of ingestion on the one hand, and between outward articulatory movements and negative, avoidance related oral movements of expectoration on the other hand. An alternative account stating that inward articulatory movements might simply be more fluent than outwards movements was suggested by Bakhtiari, Körner, and Topolinski (2016), and was indeed able to partially, albeit not fully, explain the effect.

Combining this new line of research on consonantal direction with the current state of research on familiarity, my hypothesis was that the effect of consonantal direction would not be limited to liking, but that it should also influence perceived familiarity of pseudo-words, such that inward pseudo-words would be judged as being more familiar than outward pseudo-words. The experiments presented here (total N = 1,043) tested this hypothesized effect, its applications, alternative explanations, and potential mechanisms. In a classical recognition paradigm in Experiment 1, participants were presented with inward and outward pseudo-words in a study phase and a later test phase, in which they had to indicate whether each stimulus had been presented before or not. In line with predictions, inward pseudo-words

were judged as old more often than outward ones, independent of their actual exposure status. This – together with a signal-detection-theory-based analysis finding a difference in response bias but not discriminability between inward and outward stimuli – suggested that inward consonantal direction did indeed lead to higher perceived familiarity than outward direction. The robustness of this effect was demonstrated in a marketing related context in the presence of product pictures in Experiment 2, and it was extended to explicit ratings of familiarity for fictitious brands with inward or outward names in Experiments 3a and 3b.

The alternative explanation that the effect might simply be driven by a tendency to affirm any question that is being asked when the stimulus has an inward rather than an outward consonantal pattern was ruled out in Experiment 4, which introduced a Go/No-go paradigm to the recognition test, asking participants to either react only to old or only to new stimuli. When participants needed to react only to new stimuli, the previous pattern reversed, with participants now showing fewer reactions toward inward compared to outward stimuli, supporting the notion that participants responded according to the perceived familiarity of the pseudo-words, rather than just confirming the question. The additional assumption that consonantal direction only influences familiarity, but not recollection, was tested in Experiments 5 and 6. While the manipulation in Experiment 5 was not successful in eliminating familiarity based judgments and therefore could not answer this question, a process dissociation procedure in Experiment 6 allowed to distinguish between familiarity and recollection, showing that as predicted, inward and outward pseudo-words only differed in familiarity, but not recollection.

To assess the respective contributions of liking and fluency as potential mediators of the effect, Experiment 7 first tested the subjective articulation fluency of the inward and outward stimuli used in the recognition experiments. There was only a small, non-significant tendency of inward pseudo-words being rated as easier to pronounce than outward pseudo-words. Study 8 then combined fluency ratings with familiarity ratings from Experiment 3a, old/new ratios from the recognition experiments, and liking ratings from a previous paper (Topolinski & Boecker, 2016a) and found that while all old/new ratios and familiarity ratings were significantly correlated, neither correlated with liking or fluency. Liking and fluency were moderately correlated, but neither variable mediated the effect of consonantal direction on familiarity. As a replication, Experiment 9 tested fluency for another set of stimuli used in Experiment 3b, again only finding a non-significant tendency, and Study 10 correlated these fluency and familiarity ratings with liking ratings from another study. Results confirmed the previous findings that familiarity did not correlate with liking, while liking was again moderately correlated with fluency. Fluency and familiarity showed a very small correlation, but there was again no mediation of the effect of consonantal direction on familiarity by fluency or liking. These findings suggest that the effect of consonantal direction on familiarity is independent of the effect on liking, and likely also of the stimuli's articulatory fluency.

The General Discussion examines these findings and their limitations more closely and offers potential explanations regarding the distinct mechanisms underlying the effects of consonantal direction on liking and familiarity. Possible applications of the effect on familiarity, especially in marketing and advertising, are discussed.

Zusammenfassung

In der Rekognitionsforschung wird der Begriff Vertrautheit verwendet, um das diffuse Gefühl zu beschreiben, einem Stimulus zuvor begegnet zu sein, ohne sich an die spezifische Situation oder die Umstände dieser Begegnung erinnern zu können (z.B., Jacoby, 1991; Mandler, 1980). In diesem Sinne kann Vertrautheit auch irreführend sein, das heißt, das Gefühl kann durch andere Faktoren wie zum Beispiel bestimmte Eigenschaften des Stimulus ausgelöst werden, selbst wenn der Stimulus in Wirklichkeit nie zuvor präsentiert wurde. Frühere Arbeiten haben gezeigt, dass zum Beispiel die Positivität eines Stimulus zu der Wahrnehmung führen kann, dass der Stimulus vertraut ist (z.B., Monin, 2003), und dass selbst Manipulationen oberflächlicher Stimulusmerkmale, wie beispielsweise eine erhöhte perzeptuelle Verarbeitungsflüssigkeit, den gleichen Effekt erzielen können (z.B. Whittlesea, 1993).

Neueste Arbeiten identifizierten ein weiteres Merkmal von Wortstimuli, das solche heuristisch-affektiven Effekte evozieren kann, nämlich artikulatorische Muster in Wörtern, die durch die Reihenfolge ihrer Konsonanten erzeugt werden (Topolinski, Maschmann, Pecher, & Winkielman, 2014). Diese Arbeiten induzierten systematische Einwärts- und Auswärtsbewegungen von Artikulationsbewegungen. Da einige Konsonanten eher vorn im Mund artikuliert werden, zum Beispiel an den Lippen, während andere Konsonanten weiter hinten artikuliert werden, zum Beispiel am Gaumensegel oder im Rachen, können Kunstwörter konstruiert werden, bei denen die konsonantischen Artikulationsorte entweder von vorn nach hinten, also einwärts, oder von hinten nach vorn, also auswärts, verlaufen. Topolinski und Kollegen (2014) stellten fest, dass derart konstruierte Kunstwörter, die einer einwärts verlaufenden Sequenz folgen, im Allgemeinen mehr gemocht wurden als solche, die einem auswärts verlaufenden Muster folgen. Sie erklärten diesen Effekt anhand von Assoziationen zwischen einwärts verlaufenden Artikulationsbewegungen und positiven, annäherungsbezogenen Mundbewegungen der Nahrungsaufnahme auf der einen Seite, und zwischen auswärts verlaufenden Artikulationsbewegungen und negativen, vermeidungsbezogenen Mundbewegungen des Ausspeiens auf der anderen Seite. Eine alternative Hypothese, die besagt, dass einwärts verlaufende Artikulationsbewegungen motorisch effizienter sein können als auswärts verlaufende Bewegungen, wurde von Bakhtiari, Körner, und Topolinski (2016) aufgestellt, und konnte den Effekt teilweise, wenn auch nicht vollständig, kausal mediieren.

Die Kombination dieser neuen Arbeiten zu konsonantischer Richtung mit dem aktuellen Stand der Forschung zu Vertrautheit führte zu meiner Hypothese, dass der Effekt konsonantischer Richtung sich nicht auf Präferenz beschränken würde, sondern dass er auch die wahrgenommene Vertrautheit von Pseudo-Wörtern beeinflussen sollte, insofern einwärts verlaufende Wörter als vertrauter eingeschätzt würden als auswärts verlaufende. Die hier berichteten Experimente (Gesamtstichprobe N = 1043) testeten diese Vorhersage, ihre Anwendungen, Alternativerklärungen und potentiellen Kausalmechanismen. In einem klassischen Rekognitionsparadigma in Experiment 1 wurden Probanden einwärts und auswärts verlaufende Pseudo-Wörter in einer Studierphase und einer späteren Testphase präsentiert, in der sie für jeden Stimulus angeben sollten, ob er zuvor präsentiert worden war oder nicht. In Übereinstimmung mit meinen Vorhersagen wurden einwärts verlaufende Pseudo-Wörter häufiger als alt eingestuft als auswärts verlaufende, unabhängig von ihrem tatsächlichen Darbietungsstatus. Dieser Befund – zusammen mit einer Signalentdeckungs-theorie-basierten Analyse, die Unterschiede in der Antworttendenz, nicht aber in der Sensitivität zwischen einwärts und auswärts verlaufenden Stimuli fand – legte nahe, dass einwärts verlaufende konsonantische Sequenzen tatsächlich zu höherer wahrgenommener Vertrautheit führen als auswärts verlaufende konsonantische Sequenzen. Die Robustheit dieses Effekts wurde in Experiment 2 in einem marketingbezogenen Kontext bei gleichzeitiger Präsentation von Produktbildern demonstriert; und der Effekt wurde in den Experimenten 3a und 3b auf explizite Bewertungen von Vertrautheit für fiktive Marken mit einwärts oder auswärts verlaufenden Namen generalisiert.

Die alternative Erklärung, dass der Effekt lediglich in der Antworttendenz begründet sein könnte, jegliche Frage zu bejahen, wenn der Stimulus ein einwärts anstatt auswärts verlaufendes Muster hat, wurde in Experiment 4 ausgeschlossen. Hier wurde ein Go/No-go Paradigma angewandt, in dem Probanden aufgefordert wurden, entweder ausschließlich auf alte oder ausschließlich auf neue Stimuli zu reagieren. Wenn Probanden nur auf neue Stimuli reagieren sollten, kehrte sich das bisherige Muster um und Personen zeigten nun weniger Reaktionen auf einwärts verglichen mit auswärts verlaufenden Stimuli, was die Idee bestätigte, dass Probanden entsprechend der wahrgenommenen Vertrautheit der Pseudo-Wörter antworten, anstatt lediglich der gestellten Frage zuzustimmen. Die zusätzliche Annahme, dass konsonantische Richtung ausschließlich Vertrautheit beeinflusst, nicht jedoch Rekollektion, wurde in den Experimenten 5 und 6 getestet. Während die Manipulation in Experiment 5 vertrautheitsbasierte Urteile nicht erfolgreich eliminieren und daher diese Frage nicht beantworten konnte, erlaubte eine Prozess-Dissoziations-Prozedur in Experiment 6, zwischen Vertrautheit und Rekollektion zu differenzieren, und zeigte wie vorhergesagt, dass einwärts und auswärts verlaufende Pseudo-Wörter sich nur hinsichtlich ihrer Vertrautheit unterschieden, nicht jedoch hinsichtlich ihrer Rekollektion.

Um den jeweiligen Kausalbeitrag von Präferenz und Verarbeitungsflüssigkeit als potentielle Mediatoren des Effekts zu untersuchen, erhob Experiment 7 zunächst die subjektiv eingeschätzte Artikulationsflüssigkeit der Einwärts- und Auswärts-Stimuli, die in den Rekognitionsexperimenten verwendet worden waren. Es zeigte sich lediglich eine kleine, nicht signifikante Tendenz, dass einwärts verlaufende Pseudo-Wörter als leichter aussprechbar beurteilt wurden als auswärts verlaufende Pseudo-Wörter. Studie 8 kombinierte die Artikulationsflüssigkeits-Bewertungen mit den Vertrautheits-Bewertungen aus Experiment 3a, den Alt/Neu-Urteilen der Rekognitionsexperimente und Präferenz-Bewertungen aus einer früheren Publikation (Topolinski & Boecker, 2016a) und fand, dass während alle Alt/Neu-Urteile und Vertrautheits-Bewertungen signifikant korreliert waren, keine dieser Maße mit Präferenz oder Artikulationsflüssigkeit korrelierten. Präferenz und Artikulationsflüssigkeit waren moderat korreliert, aber keine der beiden Variablen mediierte den Effekt konsonantischer Richtung auf Vertrautheit. Als Replikation testete Experiment 9 die Artikulationsflüssigkeit eines anderen Sets von Stimuli, das in Experiment 3b genutzt worden war, und fand erneut nur eine nicht signifikante Tendenz. Studie 10 korrelierte diese Artikulationsflüssigkeits- und Vertrautheits-Bewertungen mit Präferenz-Bewertungen aus einer anderen Studie. Die Ergebnisse bestätigten den vorherigen Befund, dass Präferenz nicht mit Vertrautheit korrelierte, während Präferenz erneut moderat mit Artikulationsflüssigkeit korreliert war. Artikulationsflüssigkeit und Vertrautheit zeigten eine sehr geringe Korrelation, jedoch konnte erneut keine Mediation des Effekts konsonantischer Richtung auf Vertrautheit nachgewiesen werden, weder durch Artikulationsflüssigkeit noch durch Präferenz. Diese Befunde deuten darauf hin, dass der Effekt von konsonantischer Richtung auf Vertrautheit unabhängig ist von dem Effekt auf Präferenz, und wahrscheinlich ebenso von der Artikulationsflüssigkeit der Stimuli.

Die allgemeine Diskussion in Kapitel 11 behandelt die Ergebnisse der Experimente und ihre Einschränkungen eingehender und präsentiert mögliche Erklärungsansätze in Bezug auf die distinkten Mechanismen, die den Effekten von konsonantischer Richtung auf Präferenz und Vertrautheit jeweils zugrunde liegen könnten. Potenzielle Anwendungen des Effekts auf Vertrautheit, speziell hinsichtlich Marketing und Werbung, werden diskutiert.

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Chapter 1 - Introduction

What does it mean when something feels familiar to us? We all know the situation where we see a face in the crowd and immediately experience a strong, almost haunting feeling that we know this person. Have we met them before? Have we seen their picture somewhere? Or does that person merely look confusingly similar to someone else we know? A different example of such a feeling is the phenomenon of the déjà vu, the sensation of re-living a past situation that we cannot remember specifically (Brown, 2003, 2004; Cleary, Ryals, & Nomi, 2009). It is this diffuse feeling of recognition without the ability to recall its source that defines familiarity in the context of psychological research on recognition memory (e.g., Brown & Marsh 2009; Cleary, 2004, 2008; Mandler, 1980).

The antecedents and consequences of familiarity have been subject to a vast body of research. The most commonly used and direct way to increase familiarity of a certain stimulus is to present it repeatedly (e.g., Coane, Balota, Dolan, & Jacoby, 2011). From an evolutionary standpoint, the repeated experience with a stimulus without any harmful consequences can serve as a cue that it is safe, which is in line with research finding familiar stimuli to be judged as safer than unfamiliar stimuli (e.g., Litt, Reich, Maymin, & Shiv, 2011). This is also a possible explanation for the fact that the simple repetition increases liking of a stimulus, as demonstrated in the *mere exposure effect* (Bornstein, 1989; Zajonc, 1968). Besides these effects, the greater familiarity of a stimulus elicited by repeated exposure also leads to faster and easier processing of the stimulus in future encounters. This experienced meta-cognitive feeling of ease has been termed *processing fluency* (for a review, see Alter & Oppenheimer, 2009). In line with research showing that fluent processing of a message is usually interpreted as a sign of the message's validity (e.g., Reber & Schwarz, 1999; Unkelbach, 2006), familiar statements are also judged to be true more frequently than unfamiliar statements (e.g., Begg, Anas, & Farinacci, 1992; Moons, Mackie, & Garcia-Marques, 2009; Unkelbach, 2007).

It does not always need to be the content of a stimulus that creates a sense of familiarity, however. The example of the familiar face in the crowd illustrates that it can also be the superficial features of a stimulus that evoke a feeling of familiarity; in this case, for example, it could be the shape of the eyes and the mouth that bear a close resemblance to the facial features of a known actor. Similarly, mere positivity, for instance the attractiveness of a face, can trigger familiarity (e.g., Garcia-Marques, Mackie, Claypool, & Garcia-Marques, 2004, Monin, 2003). It has been shown that illusions of familiarity can also be created by simply increasing the perceptual fluency of a stimulus through means of visual clarity (e.g., Johnston, Dark, & Jacoby, 1985; Whittlesea, Jacoby, & Girard, 1990; Whittlesea, 1993). Conversely, fluency and familiarity have also been shown to elicit greater liking of a stimulus (e.g., Lee, 2001; Reber, Winkielman, & Schwarz, 1998).

Such an effect on liking has also been found in a recent, unrelated line of research investigating the articulatory dynamics of words elicited by the direction of their consonantal pattern (Topolinski et al., 2014). Based on the phenomenon that consonants can be classified by their specific place of articulation in the mouth on a sagittal plane from the lips to the throat (e.g., Ladefoged, 2001; Maddieson, 1984), some words with multiple consonants consequently follow an inward (from the front of the mouth to the back) or an outward (from the back of the mouth to the front) directed movement when they are being articulated. Topolinski et al. (2014) created pseudo-words following these dynamics and found that people generally prefer inward wandering over outward wandering pseudo-words, which I will call the *in-out preference effect* in this work. They explained this greater liking for inward consonantal dynamics with a close resemblance of these movements to positively associated oral actions of ingestion, that is, eating and drinking. On the other hand, outward oral movements resemble negatively associated actions of expectoration, such as spitting or vomiting. The authors therefore argued that inward oral movements should be inherently approach related, and outward movements avoidance related. A different account for this in-out preference effect was recently proposed by Bakhtiari et al. (2016). They assumed that greater fluency of inward compared to outward articulatory dynamics might be responsible for the effect, since it has been widely shown that fluency can increase liking (e.g., Reber et al., 1998; Winkielman & Cacioppo, 2001). Indeed they found higher fluency for inward compared to outward pseudo-words, both when measured by subjective ratings and by reading time. This difference in fluency also partially mediated the effect of greater liking for inward compared to outward pseudo-words, but was not able to explain the effect entirely; a substantial effect independent of fluency remained.

Based on these findings and the aforementioned connections of liking, fluency and familiarity, I propose that consonantal direction influences judgments beyond liking ratings. Specifically, I hypothesize that consonantal inward compared to outward pseudo-words elicit higher perceived familiarity in a recognition paradigm, independent of their actual previous exposure. Such an effect would also hold great potential for applications in the marketing context: Particularly in the design of brand and product names, making use of such a basic principle as consonantal direction might be an extremely efficient way to not only achieve greater liking, but also instant familiarity of the thus named brands and products, thereby boosting the effectiveness of conventional, costly advertising strategies. The aim of the present work is to test the assumption of an effect of consonantal direction on perceived familiarity. In the following chapters, I will first provide a more detailed overview of the in-out preference effect, its context, and potential mechanisms. Then I will discuss research on the concept of familiarity, before presenting the experiments conducted to test the proposed in-out familiarity effect as well as to investigate its potential applications and to rule out alternative explanations, which build the core of the present work. The last studies explore the role of liking and fluency as possible mediators of the in-out familiarity effect. The implications of the results as well as potential mechanisms of the effect are examined in the General Discussion.

Chapter 2 – Effects of Articulation Dynamics

Topolinski and colleagues (2014) were the first to propose that the order of consonants in a word has an influence on the evaluation of the word. Thereby, they went beyond classical research on sound symbolism that usually focuses on specific phonemes or syllables by introducing effects of the *dynamics* of articulation. The present chapter first provides an overview of sound symbolism research by discussing studies that are relevant within the context of the effect of consonantal direction, before addressing said effect as well as its underlying assumptions and consequences in more detail.

2.1 Articulation and Sound Symbolism

A long and controversial debate in linguistics, especially in etymology, has been whether words consist of arbitrary combinations of sounds and symbols unrelated to their semantic meaning, or whether the names of the words themselves convey some meaning, as is the case in sound symbolism such as onomatopoeia. In fact, the debate can be traced back over 2000 years ago to Plato, who allowed his protagonists Socrates, Cratylus and Hermogenes to discuss this question in his dialogue "Cratylus" (original approx. 350 BC; Plato & Jowett, 1901). Although the assumption that linguistic signals are arbitrary and independent of the objects they signify was revisited by de Saussure in his study of semiology at the beginning of the 20th century (de Saussure, 1916/1959) and is still supported widely in modern linguistics, there is also an extensive body of research on sound symbolism effects suggesting that other features of words apart from semantic meaning can shape our perception and interpretation of them. Onomatopoeia is one of the most obvious examples of sound symbolism, describing that the sound of a word in its entirety imitates the sound of the object or action it denotes (e.g., crash, roar). Another phenomenon are phonesthemes (Firth, 1930/1964), which are systematic sound-meaning pairings occurring in a certain language. For example, English words with the onset of *gl* often have connotations with the concepts of light or vision (Bergen, 2004), such as *glitter*, *glow*, *glimmer*, *glisten*, *gloss*, and *glaze*, almost all of which translate into a word with *gl*-onset in German as well. Whether the latter findings challenge the general arbitrariness principle described above is a discussion that goes beyond the scope of this dissertation, but they are certainly informative for psychological research on the processing and understanding of language.

Perhaps the most prominent example of sound symbolism in the psychological domain has been introduced by Köhler (1929, 1947) and has later been named the *bouba-kiki* effect after the stimuli used in subsequent adaptations of the task (Ramachandran, & Hubbard, 2001). In this test participants are presented with two shapes similar to the ones illustrated in Figure 1. They are then told that one of the shapes is called a *kiki* and one a *bouba* and that they should guess which name belongs to which shape. Overwhelmingly, participants assign the name *kiki* to the object with sharp, pointed angles presented on the left in Figure 1, while they associate *bouba* with the more rounded object on the right.

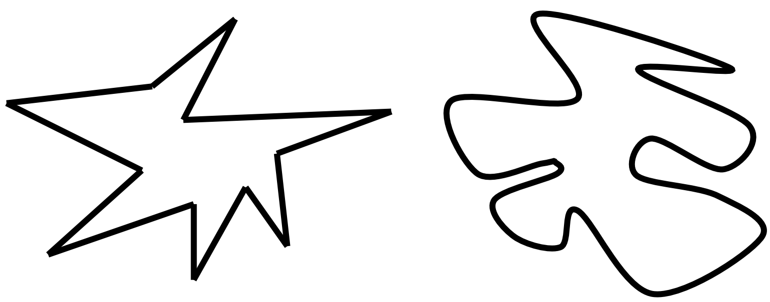


Figure 1: Examples of the type of shapes used in a *bouba-kiki* task, with the left representing a shape typically associated with *kiki*, and the right representing a shape typically associated with *bouba* (illustration rendered by the author based on examples by Ramachandran and Hubbard, 2001).

The explanation behind this strong and robust effect is that articulating *kiki* involves short, sharp sounds almost like a staccato which match the sharp inflections of the left shape, whereas the soft [b] phonemes and the back vowels in *bouba* correspond with the soft roundness of the right shape. The alternative account that the *bouba-kiki* effect might not be based on a sound-shape association at all, but rather on a simple matching effect between the shape of the objects and the sharp versus round shapes of the letters used to spell the names could be ruled out by demonstrations of the effect in children as young as 2.5 years (Maurer, Pathman, & Mondloch, 2006). In fact, recent findings suggest that the *bouba-kiki* effect actually rests upon three different phonetic features that are optimally combined in the *kiki* and *bouba* stimuli: the inclusion of front versus back vowels, the inclusion of voiceless versus voiced consonants, and the place of articulation of the consonants (D'Onofrio, 2014), of which the consonantal features seem to have a greater impact than the vowels (Fort, Martin, & Peperkamp, 2015).

Apart from sound-shape associations, there have been numerous studies showing other associative links between the sound of certain phonemes and the attributes of the objects they denote. While some of these studies tested consonants (e.g., Newman, 1933), most have concentrated on the manipulation of vowel sounds and their implications. A potential reason for this imbalance might lie in the fact that there are simply more distinct consonants than vowels, and that consonants differ on more dimensions than vowel sounds, for example in their phonation (i.e., whether they are voiced or voiceless), their modulation of the airflow, and their place of articulation. Chapter 2.2.1 provides a more detailed overview of the articulation of consonants. Vowels, on the other hand, are by definition articulated with an open vocal tract and almost always voiced (with exceptions for example in Japanese and some Native American languages). They differ mainly in their frequency (i.e., pitch) as well as the position of the tongue during articulation (further to the front or the back of the mouth). These two factors are closely connected, with front vowels (such as [iː] and [eː]) having higher frequencies than back vowels (such as [oː] and [uː]). In line with this distinction, sound symbolism research has shown that objects named with pseudo-words or words in a foreign language containing front vowels are estimated to be smaller (Sapir, 1929), harder (Bentley & Varon, 1933; Koriat & Levy, 1977), and brighter (Koriat & Levy, 1977; Newman, 1933) compared to those containing back vowels (for a review, see French, 1977).

Another line of research has addressed the effect that front vowels are generally judged more positively than back vowels. This phenomenon has been attempted to be explained by the frequency code hypothesis (Ohala, 1980, 1994) which states that the higher frequency (i.e., pitch) sounds associated with front vowels are also a sign of a smaller vocal tract, and therefore indicative of small size. Higher pitched sounds may therefore have evolutionary been used to give the impression of small size and to signal submission and appeasement, whereas the lower frequency sounds associated with back vowels would have signaled large size and/or aggression. A different approach for the phenomenon has been formulated as the articulatory feedback hypothesis (Rummer, Schweppe, Schlegelmilch, & Grice, 2014): Rummer and colleagues assume that the reason for a preference of front vowels lies in the fact that the same contraction of the zygomaticus major muscle responsible for smiling and laughing occurs when articulating a front vowel such as a long [iː]. Articulation of back vowels such as [oː] and [uː], on the other hand, involves the contraction of the orbicularis oris muscle, which counteracts activity of the zygomaticus major. In two studies, Rummer et al. (2014) tested the valence-vowel association bidirectionally. First, they demonstrated that a positive (negative) mood induction increased the frequency of the letter *i* (the letter *o*) in pseudo-words participants were asked to invent. Secondly, they showed that concurrent articulation of the vowel [iː] led to higher funniness ratings of presented cartoons than concurrent articulation of the vowel [oː].

Effects of vowel preferences were also demonstrated in an applied context (e.g. Coulter & Coulter, 2010; Klink, 2000; Lowrey & Shrum, 2007). Lowrey and Shrum (2007) created-pseudo brand names with either front or back vowels and presented them with different product categories. The results showed that participants preferred front vowels when the to be named object was supposed to be small or sharp, such as a knife, but back vowels were preferred when an object was positively associated with large size and heaviness, such as an SUV. These findings highlight that the preference for front vowels is by no means universal, but depends on the attributes of the denoted object (see also Yorkston & Menon, 2004).

Recently, effects of vowel sound symbolism have even been extended beyond the measurement of attributes and associations. For instance, it has been shown that the inclusion of front versus back vowels can influence mental construal and thereby alter preferences according to the current mode of thinking (Maglio, Rabaglia, Feder, Krehm, & Trope, 2014). Maglio et al. (2014) combined the findings on attributes associated with front versus back vowels with the assumptions of construal level theory, hypothesizing that front vowels would elicit concrete, low-level construal, whereas back vowels would increase an abstract, high-level mode of thinking. In several studies, they demonstrated that this was indeed the case: One experiment, for example, used the same names *Frish* and *Frosh* designed as fictitious ice cream brands by Yorkston & Menon (2004), but added the information that the ice cream was either poorly tasting, but well accessible, or delicious, but poorly accessible. When the ice cream was named *Frosh*, participants clearly preferred the delicious ice cream despite its poor accessibility, while this difference was attenuated for the ice cream *Frish* (i.e., accessibility became more important for the decision), indicating that the front vowel did indeed shift the mode of thinking from a more abstract to a more concrete construal. In a very recent study, Rabaglia, Maglio, Krehm, Seok, and Trope (2016) also demonstrated that front (back) vowels are associated with smaller (greater) distance, to the point that it influences participants' actions: When throwing a ball at an unknown object in the distance that was named with a pseudo-word including a back vowel, participants threw the ball farther than when the name contained a front vowel.

The findings presented above emphasize that sound symbolism is an old, but still thriving field of research that continues to provide new insights into the origins of words and our perceptions of them. In fact, a very recent article provided evidence for a number of robust sound-meaning associations in an extensive investigation of words across several thousand languages (Blasi, Wichmann, Hammarström, Stadler, & Christiansen, 2016), among which was the previously described association between the vowel [i] and small size. Since these associations were evident across many different language families and in geographically distant areas that (pre-)historically had no contact, many of the associations have very likely developed independently, a finding that challenges the general arbitrariness principle of language described in the introduction of this subchapter. However, with regard to psychological research on the effects of sound symbolism, investigations of consonants have been rare, and both research on consonants and vowels has focused on effects of the mere occurrence of certain phonemes or letters in words. In a line of research different from sound symbolism, Topolinski et al. (2014) were the first to consider the psychological consequences of articulation dynamics elicited by specific *sequences* of phonemes, which will be introduced in more detail in the following section.

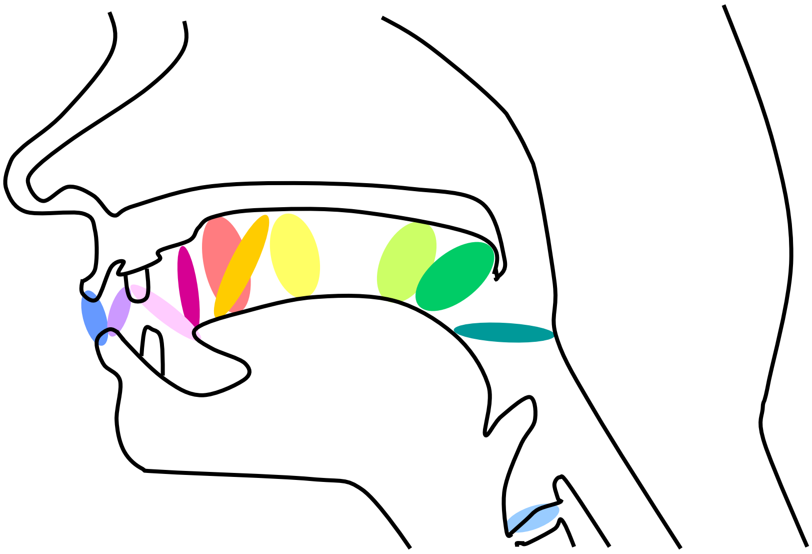
2.2 Effects of Consonantal Direction

To investigate the effects of consonantal articulation dynamics, it is important to first understand the characteristics of the articulation of consonants. The following subsection therefore provides an overview of the different classifications of consonants.

2.2.1 The Articulation of Consonants

A consonant – in contrast to a vowel – is generally defined as a phoneme or speech sound that is produced by partial or complete closure of the vocal tract (e.g., Ladefoged, 2001; Maddieson, 1984). This happens when a part of the mouth called the active articulator (i.e., the tongue or the lips) touches another part of the mouth that serves as the passive articulator (e.g., the teeth or the hard/soft palate). Interestingly, while vowels can be pronounced quite flexibly in different positions of the tongue and lips, each consonant has a very specific spot where it is articulated. A [p] sound can simply not be produced without the lips touching, and a [k] sound is not possible without contact between the tongue and the soft palate. Therefore, these specific spots are called *places of articulation*, and can be grouped into different categories. Figure 2 displays these consonant categories as defined by their place of articulation and lists the phonemes associated with each category using the official symbols defined by the International Phonetic Alphabet (IPA; International Phonetic Association, 1999). The list includes all phonemes that exist in the German language because that is the language and population this dissertation is based on. Because more and more Anglicisms find their way into German vocabulary, though, I also included the two phonemes [θ] and [ð] associated with the English *th* and the phoneme [ɻ] associated with a type of American English *r* to give examples of dental and retroflex consonants, respectively, that otherwise do not occur in German. There are no phonemes in the pharyngeal category neither in German nor in any other Ingo-Germanic language; they occur primarily in some Semitic languages such as Arabic and Hebrew.

Note that whenever consonants are mentioned in the present work, they refer to consonants as the aforementioned type of phonemes, not as specific letters. In English, for example, the phoneme [s] can be represented both by the letter S (as in *summer*: [ˈsʌmɚ]) and C (as in *certain*: [ˈsɜːrt-]). On the other hand, the letter C can not only represent the phoneme [s], but also [k] (as in *car*: [kɑːr]). Similar cases exist in German, where the letter V can represent the phonemes [v] and [f], but [v] can also be written as W, and [f] can be written as F. In the experiments presented in this work as well as in the studies by Topolinski and colleagues on the effects of consonantal articulation dynamics, letters naturally had to be used to present written stimuli; only those letters were therefore chosen which unambiguously refer to a specific phoneme in the native language of the tested population.



1	2	3	4	5	6	7	8	9	10	11
biliabial	labio-dental	dental	alveolar	post-alveolar	retro-flex	palatal	velar	uvular	pharyn-geal	glottal
p b m	f v ɱ p͡f	θ ð	t d n s z l t͡s	dʒ ʃ ʒ t͡ʃ	ɻ	ç j	k g x ŋ	χ ʁ ʀ		ʔ h

Figure 2: Places of articulation and associated phonemes as occurring in the German language (plus dental and retroflex consonants). The colored oval shapes illustrate the movements by which passive and active articulators meet for the different types of consonants as referenced in the table; for example the upper and lower lip for bilabial consonants (1, blue) or the tongue and the upper front teeth for dental consonants (3, light pink).

Apart from their places of articulation, consonants can also be defined by their phonation, or voicing, meaning whether their articulation involves vibration of the vocal folds in the larynx (voiced consonants) or not (voiceless consonants). There are often two phonemes that are identical in their place of articulation but differ in their phonation (e.g., bilabial, [p] and [b]; labiodental, [f] and [v]; velar, [k] and [g]). Consequently, phonation is completely independent of the places of articulation, with both voiced and voiceless consonants occurring at almost any place along the sagittal plane (see Figure 2).

Another characteristic of consonants is the so called manner of articulation which describes how the airflow is obstructed or modulated during articulation. The manner of articulation differentiates – among others – between *stops*, that is, consonants for which the airflow is completely obstructed by full occlusion of the vocal tract (e.g., [p], [b], [t], [d], [g],

[k]), *fricatives*, consonants that only partially obstruct the airflow, leaving a small channel open through which air is pressed in a way that it creates turbulence and noise (e.g., [f], [v], [s], [z]), and *nasals*, consonants for which the airflow through the mouth is completely obstructed, but the soft palate is lowered, permitting a free airflow through the nose (e.g., [m], [n]). Again, as the examples show, this classification is independent of the place of articulation; a stop, for example, can be produced at the front of the mouth, as in [b], or far in the back, as in [k].

When investigating articulation dynamics defined as a movement from the front of the mouth to the back or vice versa, the place of articulation is the most appropriate characteristic for the categorization of consonants. Phonation and manner of articulation, on the other hand, do not provide information about the localization of articulation, and are therefore irrelevant for the classification of consonants in the present work.

2.2.2 The In-Out Preference Effect

In accordance with the places of articulation as illustrated in Figure 2, Topolinski et al. (2014) argued that articulating a word with multiple consonants could produce certain articulatory patterns. For example, the articulation of a word that includes a bilabial consonant (e.g., [b]) and a velar consonant (e.g. [k]) in that order, such as the word *book*, would wander *inwards*, meaning from the front of the mouth to the back. In the opposite order, a word starting with a velar consonant followed by a bilabial consonant, such as the word *gap*, would be articulated *outwards*, wandering from the back of the mouth to the front. An inward articulatory movement is therefore very similar to another oral inward movement, namely the ingestion of food and liquids (Rozin, 1996). Since supplying the body with water and nourishment is the primary function of the oral system and a basic human need, people usually enjoy satisfying that need by eating and drinking, associating these actions with positive feelings (e.g., Topolinski & Bakthiari, 2016; Experiment 1). The opposite, outward pattern on the other hand resembles oral movements of expectoration, such as spitting or coughing something out, or even vomiting (Goyal & Mashimo, 2006). These are usually either voluntary reactions to tasting something disgusting, as in the case of spitting something out, or involuntary actions automatically initiated by the body to expel something dangerous, for example stuck food from the trachea (Fontana & Lavorini, 2006; Pitts, 2014) or rotten or poisonous substances from the stomach (Horn, 2008; Mitchelson, 2004; cf. Fessler & Arguello, 2004). Sayings such as “the stomach revolts” illustrate that people are aware that these actions are seldom based on voluntary decisions, but rather are automatic reactions of the body itself to something extremely negative.

Because actions of ingestion are perceived positively (Topolinski & Bakthiari, 2016; Experiment 1), words with inward consonantal patterns should be liked more than words with an opposite, outward pattern, because the matching oral movements of spitting, coughing or vomiting are clearly perceived negatively (Rozin, 1999). To test this assumption, Topolinski et al. (2014) created pseudo-words consisting of letters that refer to front (bilabial and labiodental; B, M, P, W), middle (alveolar; T, D, N, L, S), and back consonants (velar and uvular; G, K, R) in German phonation. Every inward pseudo-word included one letter from each category in the order front-middle-back, with random vowels being inserted to create pronounceable pseudo-words (e.g., PUDOKA). A matching outward word was then built by simply reversing the order of consonants, while keeping the random vowels in their previous order (e.g., KUDOPA). This was especially important because as described in subchapter 2.1, the selection of different vowels can elicit a preference effect by itself (e.g., Ohala, 1994; Rummer et al., 2014), thereby confounding the effect of inward versus outward consonantal direction (in-out preference effect). Over several experiments on native German and native English speaking samples (with pseudo-words adjusted to English phonation for the latter), Topolinski et al. (2014) were indeed able to show that people liked inward pseudo-words better than outward pseudo-words.

One might wonder why the authors created pseudo-words instead of testing real words which feature and inward or outward consonantal pattern. The first reason is that, as described above, it is important to be able to control for confounding factors such as vowels included in a word. In existing words, this would be impossible to keep constant between inward and outward words, let alone controlling for other features such as word length, number of vowels and consonants, and occurrence of double consonants and diphthongs, among others. The other reason is that real words always entail a semantic meaning. This semantic meaning is seldom neutral across contexts; there is usually some inherent valence attached to a word, as well as other idiosyncratic positive or negative associations. Introducing this variance into the stimulus pool would render it impossible to differentiate between liking evoked by the consonantal direction and liking based on semantic meaning. Therefore, the study of pseudo-words offers a better controlled assessment of the effects of articulatory dynamics induced by consonantal direction.

The in-out preference effect has been shown consistently for different types of stimuli in several studies on English, German and Portuguese speaking samples, in studies conducted by several independent research groups (e.g., Godinho & Garrido, 2016; Kronrod, Lowrey, & Ackerman, 2015; Topolinski et al., 2014; Topolinski & Boecker, 2016a) and is currently been replicated in French and Spanish. Topolinski and Boecker (2016a) extended the in-out effect to other stimuli to explore the nature and boundary conditions of the effect of consonantal direction in more detail. While the use of identical random vowels in pairs of inward and outward stimuli in the experiments of the original paper (Topolinski et al., 2014) ruled out simple confounding effects by the occurrence of front versus back vowels, there are other potential vowel effects that the original paper did not take into account. Specifically, from the existing differentiation between front and back vowels one can derive the hypothesis that there might be an effect of vowel direction based on the same principles as the effect of consonantal direction. This assumption was tested by creating pseudo-words that consisted of one front and one back consonant, as well as one front and one back vowel each, in a vowel-consonant-vowel-consonant sequence. By the different order of the two vowels and the two consonants in each pseudo-word one could distinguish four groups of stimuli: Those which wandered a) both consonantally and vocally inwards, b) both outwards, c) consonantally inwards but vocally outwards, d) consonantally outwards but vocally inwards. Results showed that while the effect of consonantal correction remained stable across experiments and both when stimuli were presented auditorily (Topolinski & Boecker, 2016a; Experiments 2a & 2b) or in a written format (Experiments 1a & 1b), no stable main effects or interaction effects were found regarding vowel direction (Experiments 1a-2b). This can be explained by the fact that vowels can differ in their articulation based on the context of consonants and other vowels, and that they can only be roughly categorized as front or back vowels without having specific places of articulation associated with them. In fact, Topolinski and Boecker (2016a; Experiments 3-6) demonstrated that vowels are not at all necessary for the in-out preference effect to occur: When presenting mere consonantal letter pairs that either wander inwards (e.g., MK) or outwards (e.g., KM), without any vowels in between and after excluding all letter pairs that resulted in any meaningful abbreviations, participants again liked inward letter pairs better then outward letter pairs.

Another question addressed by Topolinski and Boecker (2016a) was whether the distance between two consonants moderates the strength of the in-out preference effect. It is plausible that a greater oral movement that involves the entire mouth from the front to the back or the other way around would elicit a stronger effect than a small movement that for example only moves from the lips to the hard palate or from the hard to the soft palate. Pseudo-words were therefore designed in a consonant-vowel-consonant-vowel order combining different consonants with smaller and larger distances in an inward and outward manner, including random vowels. A small movement would for example involve a movement from a labio-dental to an alveolar consonant (e.g., FOTA) or the other way around (e.g., TOFA), whereas a very large distance would involve a bilabial and a uvular consonant, for example (e.g., MORU versus ROMU; see Figure 2 for an impression of the distances between different categories of consonants). The in-out preference effect did indeed interact with the magnitude of the distance between consonants, with large distances creating a strong, significant effect, while the small distances only produced a non-significant tendency (Topolinski & Boecker, 2016a; Experiment 7). These results demonstrate that a larger oral movement augments the effect by evoking stronger differences on liking between consonantal inward and outward words.

Finally, more complex patterns of inward and outward articulatory movements have been tested. By combining stimuli from the original paper on the in-out preference effect, it was possible to build longer pseudo-words that feature a consonantal pattern that either wanders first inward, then outward, or vice versa (Topolinski & Bakhtiari, 2016). Since it was assumed and confirmed experimentally that oral movements that follow an inward-outward pattern are more negatively associated (i.e., with taking something into the mouth and spitting it out again) than movements that follow an outward-inward pattern (i.e., chewing food or sucking on hard candy), participants liked outward-inward pseudo-words more than inward-outward pseudo-words. However, a recent study which tested these stimuli in the context of shorter stimuli that clearly wandered either inwards or outwards did not find any effect for these longer, complex stimuli (Lindau & Topolinski, 2016). It is possible that the length and complexity kept participants from reading the pseudo-words thoroughly when easier, shorter stimuli were present, or that the effect of the more complex patterns is too weak to persist next to the clear in-out effect. Further research on complex articulatory patterns might clarify this question.

2.2.3 Applications of the In-Out Preference Effect

There have been several studies on potential applications of the in-out preference effect. In the original paper (Topolinski et al., 2014), first applications were already demonstrated, showing that when choosing possible chat-partners, participants chose partners with inwards names over those with outward names (Experiment 7). Furthermore, when participants were asked to rate how much they liked inward and outward pseudo-words as names for characters in a computer game, inward names were preferred over outward names, irrespective of whether the character that needed to be named was supposed to be a hero or a villain (Experiment 8). This is an interesting finding because it suggests that the in-out preference effect cannot be modulated by the valence of the target. The same was found for applications in a consumer context: People liked brands with inward names better than those with outward names (Kronrod et al., 2015; Topolinski, Zürn, & Schneider, 2015), even when they represented rather negatively associated products, for example pest control (Topolinski et al., 2015). In addition, participants displayed a higher willingness-to-pay for products with inward compared to outward names (Topolinski et al., 2015).

In line with the association of inward consonantal patterns and ingestion, it was also shown that pictures of food presented as foreign dishes with inward names were judged as being more appetizing than dishes with outward names (Topolinski & Boecker, 2016b). The in-out preference effect can be modulated, however, when objects named with either inward or outward pseudo-words are associated with different oral affordances (Topolinski, Boecker, Erle, Bakhtiari, & Pecher, 2017). For example, whereas inward names were preferred over outward names for products associated with ingestion-related inward oral movements, such as lemonade or mouth wash, this effect was reduced and in some cases even reversed for products associated with expectoration-related outward mouth movements, such as toxic chemicals or bubble gum. This modulation could not be explained by the valence of the different products. Taken together, these results raise questions about the underlying mechanism of the in-out preference effect, which will be discussed in more detail in the following subchapter.

Chapter 3 – Mechanisms behind the In-Out Preference Effect

As described above, the in-out preference effect is assumedly based on an association between articulation-related and ingestion-related oral inward movements as well as between articulation-related and expectoration-related oral outward movements. But what exactly is the mechanism that links these proposed associations to greater (lesser) liking of inward (outward) pseudo-words and are there alternative explanations of the effect? So far, two possible accounts have been proposed in the different publications on the effect: approach-avoidance motivation, which is discussed in the following subchapter 3.1, and fluency, which is discussed in subchapter 3.2.

3.1 Approach-Avoidance Motivation

The initial theoretical framework considers the in-out preference effect to be a result of an affective and motivational state of approach versus avoidance (Topolinski et al., 2014). This concept shall therefore be introduced and discussed in this subchapter, with a theoretical outline of how it might relate to the in-out preference effect.

3.1.1 Conceptions of Approach and Avoidance

Simply put, people are motivated to seek pleasure and to avoid pain (e.g., Gray, 1982), which is why they approach positive, appealing stimuli and avoid negative, aversive stimuli (e.g. Carver & Scheier, 1990; Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Elliot, 2008; Higgins, 1997; Strack & Deutsch, 2004). Apart from a spontaneous reaction to an automatically evaluated stimulus (e.g., Chen & Bargh, 1999), approach and avoidance motivation can also be understood as a regulatory focus of promotion or prevention (Higgins, 1997), meaning whether a person actively strives for a positive outcome (promotion) or is primarily motivated to avoid a negative outcome (prevention). Such a promotion focus as opposed to a prevention focus is associated with a number of beneficial behavioral and emotional consequences in the domains of risk taking (Zou & Scholer, 2016), bargaining success (Galinsky, Leonardelli, Okhuysen, & Mussweiler, 2005), relationship satisfaction (Molden, Lucas, Finkel, Kumashiro, & Rusbul, 2009), and personal well-being (Manczak, Zapata-Gietl, & McAdams, 2014), but it can also lead to negative outcomes, for example more self-interested behavior at the expense of the group’s joint success (Zaal, Van Laar, Ståhl, Ellemers, & Derks, 2015).

But even when regarding approach and avoidance at the level of reactions towards spontaneously evaluated positive or negative stimuli, these reactions do not necessarily rely on an inalterable automatic process; instead, they can be influenced by higher order goals. For example, smokers with a strong motivation to quit exhibit an increased startle reflex toward tobacco related stimuli (Gantiva, Ballén, Casas, Camacho, Guerra, & Vila, 2015; Muñoz, Idrissi, Sánchez-Barrera, Fernández, & Vila, 2011), although the startle reflex is an avoidance reaction (e.g., Bradley, Cuthbert, & Lang, 1999; Lang, Bradley, & Cuthbert, 1990) and tobacco related stimuli are generally appetitive for smokers. This shows that the goal to quit smoking can change the perception of a usually positive stimulus and elicit avoidance. Similarly, the same asymmetric activity in the prefrontal cortex that is associated with approaching positive stimuli (left PFC) and avoiding negative stimuli (right PFC; e.g., Davidson et al., 1990) can also be found when people need to approach *negative* stimuli and avoid *positive* stimuli (Berkman & Lieberman, 2010), indicating that the asymmetric prefrontal activity is related to approach versus avoidance motivation, rather than positive versus negative valence.

3.1.2 The Bodily Component of Approach-Avoidance

When speaking about approach and avoidance motivation, the wording alone already implies a physical aspect, a movement towards something (approach) versus keeping or increasing distance to something (avoidance). In line with this idea, there is an abundance of research on approach and avoidance that relates to the concept of embodied cognition. The idea of embodied or grounded cognition is that in the same way cognition and affect evoke bodily responses and behavioral actions, such behaviors and bodily states can in turn influence affect and cognition (e.g., Barsalou, 2008; Glenberg, Witt, & Metcalfe, 2013; Niedenthal, 2007; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Semin & Smith, 2008;). With regard to approach and avoidance, there is a large body of research that has investigated this bidirectional link from both perspectives.

Influence of stimulus valence on approach-avoidance reactions. The most prominent studies in this line of research used arm movements as realizations of approach and avoidance actions. Both Solarz (1960) and Chen and Bargh (1999) let participants evaluate positive and negative target words by either pushing or pulling movements. While Solarz (1960) presented target words on a movable stage, Chen and Bargh (1999) used a lever to induce push and pull reactions. Because pushing a lever involves extension of the arm, it imitates the avoidance movement of pushing something *away*, whereas pulling a lever involves arm flexion, thereby imitating pulling something *towards* the body in an approach movement. In accordance with the approach and avoidance associations of the movements, responses to *negative* stimuli were faster when the response required *pushing* the lever rather than pulling it, while responses to *positive* stimuli were accelerated when participants were supposed to *pull* the lever rather than push it (Chen & Bargh, 1999). This facilitation of lever movements also extends to novel valenced stimuli such as foreign words (Duckworth, Bargh, Garcia, & Chaiken, 2002), and has been demonstrated in the domain of self-control to measure motivation to approach goals and to avoid temptation (Fishbach & Shah, 2006).

While these findings might indicate that the positive or negative valence facilitated the specific arm movements corresponding to approach and avoidance (see Cacioppo, Priester, & Bernston, 1993), there is other research demonstrating that the valence can nonspecifically facilitate any movements that reduces or increases distance to the target, respectively (e.g. Krieglmeyer & Deutsch, 2010; Markman, & Brendl, 2005; Seibt, Neumann, Nussinson, & Strack, 2008; van Dantzig, Pecher, & Zwaan, 2008). Markman and Brendl (2005) showed that when participants' names were presented on screen together with target words, participants were faster in moving positive words towards their name and negative words away from their name, irrespective of whether this movement required a pulling (arm flexion) or pushing (arm extension) action. This finding supports the motivational account that positive or negative valence of a target facilitates any movement that serves the approach (i.e., distance reduction) or avoidance (i.e., distance increase) of the target, respectively. This account is also strengthened by further studies employing visual enlargement or reduction of the stimulus on the screen to give the impression that the stimulus moves towards or away from the person (Rinck & Becker, 2007; see also Krieglmeyer & Deutsch, 2010; van Dantzig et al., 2008), as well as other measures of approach-avoidance behavior such as the manikin task (Krieglmeyer & Deutsch, 2010; see also De Houwer, Crombez, Baeyens, & Hermans, 2001), in which a manikin is moved towards or away from positive and negative words on screen by using the *upwards* and *downwards* keys. A compatibility effect was found for positive-towards and negative-away pairings, irrespective of the direction of key press. This effect was even found when the approach- avoidance movements were not used to distinguish words for their valence, but for their grammatical category (Krieglmeyer & Deutsch, 2010; Experiment 2), supporting the view that stimuli are automatically evaluated without specific instructions.

Separately from these findings supporting a motivational view of the link between stimulus valence and approach-avoidance responses, another account exists that assumes evaluative coding of motor responses to be responsible for the effect. It states that when the goal to evaluate targets is active, changing the label of a reaction movement will also change the facilitation of that movement as an approach or avoidance response (Eder & Rothermund, 2008): When *push* lever movements were labeled as *upwards* and *pull* movements as *downwards*, which reversed the evaluative meaning of the movements, the facilitation effect also reversed, with *positive* words now being faster evaluated by *push/upward* movements and *negative* words being faster evaluated by *pull/downward* movements. This account therefore relies on the principle of a common coding of stimulus and response according to the theory of event coding (Hommel, Müsseler, Aschersleben, & Prinz, 2001), rather than specific movement facilitation or motivational aspects, a view that has also been promoted by Lavender and Hommel (2007). Importantly, an evaluative goal must be activated for a common evaluative coding of stimulus and response to occur, which explains why the effect is highly diminished or even eliminated completely when instructions to evaluate a target stimulus for valence are absent (Eder & Rothermund, 2008; Lavender & Hommel, 2007).

Krieglmeyer, Deutsch, De Houwer, and De Raedt (2010) tested the two different accounts of motivational orientation versus evaluative coding against each other in an adapted version of the manikin task and found that both evaluative coding and motivational orientation had a main effect on response latency, with compatible trials eliciting faster responses than incompatible ones (for a meta-analysis, see Laham, Kashima, Dix, & Wheeler, 2015). When the task did not involve an evaluative goal, however, effects of evaluative coding vanished, while effects of motivational compatibility persisted. It therefore seems as if both mechanisms described by the two accounts exist in parallel, but while the automatic evaluation of valenced stimuli is sufficient for the motivational approach-avoidance effect to occur, an evaluative goal is necessary for a facilitation effect based on common coding.

Influence of motoric approach-avoidance actions on stimulus evaluation. That the causal relationship between approach and avoidance movements and positive and negative evaluations is indeed bidirectional has been shown first by Cacioppo, Priester, and Bernston (1993). They instructed participants to put their forearms either on top or underneath a table top and to press the hands against it. The arms thereby are either extended (when pressing the hands down on the table top) or flexed (when pressing the hands upwards against the lower surface). Participants then performed a rating task, indicating how much they liked neutral Chinese characters. In line with the assumption that arm flexion is part of an approach movement, whereas arm extension is part of an avoidance movement, the Chinese characters were evaluated more positively under the performance of arm flexion rather than extension (Cacioppo et al., 1993). Importantly, the mere motor action of arm flexion or extension alone cannot elicit this effect; the motivational compatibility between the action and the target as a means of approach or avoidance is the crucial mechanism behind it (Centerbar & Clore, 2006). In other words, participants apparently interpreted their bodily state as a motivation to approach or avoid the target, attributing that motivation to the valence of the target. This notion is also supported by the finding that faster classifications of positive (negative) stimuli can also be obtained by simply giving participants the *impression* of moving towards (away from) the screen using an optical illusion without any actual movement (Neumann & Strack, 2000). In line with the findings on the motivational account of the affect to action link described above, the effect even remained robust in a lexical decision task, that is, without a conscious evaluative goal (Neumann & Strack, 2000; Experiment 3). Based on the assumption that negative affect leads to deeper processing and higher cognitive control in order to gather information about a potentially harmful situation (e.g., Mitchell & Phillips, 2007; Schwarz & Clore, 1983), Koch, Holland, and van Knippenberg (2008) demonstrated that avoidance in contrast to approach arm movements decreased reaction latencies for incongruent trials in a Stroop task (Stroop, 1935) and a task switching paradigm. This effect could be replicated using whole body movements, namely stepping towards versus away from a target stimulus (Koch, Holland, Hengstler, & van Knippenberg, 2009).

According to research in line with the evaluative coding account, performing a motor movement that matches the valence of a to-be-evaluated target in response to a secondary task can also impair the evaluation of the target instead of facilitating it (Eder & Klauer, 2007, 2009). In a study by Eder and Klauer (2009), for example, participants had to push or pull a lever in response to presented single or double tones. Simultaneously, they saw positive and negative target words and were supposed to indicate their valence by pressing one of two assigned buttons on the lever. In line with the common coding account, the valence judgment of a target word was slowed down when participants had to perform a congruent motor movement at the same time for the tone task. The theoretical assumption behind this effect is that the action plan already occupies the valence code that is needed for the evaluation of the stimulus, thereby interfering with the latter judgment. It is important to note, however, that this effect was observed in a dual task design in which the approach-avoidance movements were performed in reaction to a different set of stimuli than the to-be-evaluated targets.

3.1.3 Approach-Avoidance and the In-Out Preference Effect

Topolinski et al. (2014) argued that the greater liking for inward compared to outward pseudo-words was based on approach versus avoidance motivation elicited by the articulation of the respective consonantal pattern. As described in subchapter 2.2.2, the ingestion-related actions associated with articulatory inward movements are usually perceived as positive, while expectoration-related actions associated with articulatory outward movements are perceived as negative. The reason for this is that people experience eating and drinking as pleasurable. Apart from a physical feeling of hunger, people experience appetite, a desire to consume certain foods. This consumption is the ultimate approach behavior, an action of absorbing the stimulus (i.e., delicious food). In contrast, spitting or vomiting something out to remove disgusting and potentially harmful substances from the body is the ultimate avoidance behavior – not only pushing something away, but pushing it out (e.g., Angyal, 1941; Rozin & Fallon, 1987). It is not surprising therefore that approach-avoidance reactions, behaviorally and neurally, have been tested with appetizing versus disgusting stimuli, since they elicit clear approach-avoidance motivations (Davidson et al., 1990; Kakoschke, Kemps, & Tiggemann, 2015; Piqueras-Fiszman, Kraus, & Spence, 2014). For patients with eating disorders such as anorexia nervosa, the approach motivation towards food is disordered (Neimeijer, de Jong, & Roefs, 2015; Paslakis et al., 2016). Findings on potential retraining of food-approach associations in healthy subjects, though, for example to boost a diet, so far remain inconsistent (e.g., Becker, Jostmann, Wiers, & Holland, 2015; Dickson, Kavanagh, & MacLeod, 2016; Kemps, Tiggemann, Martin, & Elliott, 2013; Schumacher, Kemps, & Tiggemann, 2016).

The inward and outward articulatory movements induced by consonantal direction that rely on similar motor patterns as the oral movements of ingestion and expectoration could therefore produce approach versus avoidance motivation. Importantly, this articulation does not have to be overt, because the effect also occurs under silent reading (Topolinski et al., 2014; Topolinski & Boecker, 2016a). This can be explained by research showing that silent reading of a stimulus automatically triggers a covert motor simulation of its articulation called *subvocalization* (e.g., Edfeldt, 1960; Hardyck, Petrinovich, & Ellsworth, 1966; Hardyck, & Petrinovich, 1970; see also Stroop, 1935). Therefore, even silently reading an inward (outward) pseudo-word could evoke an approach (avoidance) motivation which should then translate to the evaluation of that pseudo-word, creating the in-out preference effect.

However, there is accumulating evidence to the contrary: First of all, following the argument that associations with ingestion versus expectoration movements underlie the effect, differences in liking for inward compared to outward pseudo-words should be especially large for edible products. Topolinski and Boecker (2016b) found higher palatability for inward compared to outward pseudo-words (d_z = 0.32), but when calculating d_z from the paired-samples *t*-tests reported in the original paper (Topolinski et al., 2014), it turns out that this effect size is comparable to those for liking of names of persons (Experiment 3: d_z = 0.32), and companies (Experiment 2: d_z = 0.29), and is even smaller than the effect sizes for simple liking ratings of the pseudo-words without a cover story (all d_zs > 0.39). Secondly, the experiments by Topolinski et al. (2017) described in subsection 2.2.3 showed that the in-out preference effect could be modulated when presenting participants with products with different oral affordances, and that this effect could not be explained by the valence of the products. Specifically, participants did not prefer inward over outward pseudo-words as names for bubble gum, but even showed a reverse tendency (Experiment 5), although bubble gum was rated very positively in the study. It is very unlikely therefore that bubble gum should have elicited an avoidance motivation. Rather, it seems like a general motor matching between the oral action associated with bubble gum (i.e., moving it to the teeth and blowing air out to produce bubbles) and outward articulation patterns evoked the tendency to prefer outward pseudo-words as names for bubble gum. Finally, several studies have shown that inward pseudo-words are also preferred as names for negative targets, such as villains (Topolinski et al., 2014; Experiment 8) or pest control products (Topolinski et al., 2015; Experiment 1). This can hardly be explained by elicited approach motivation, indicating that there may be a different process driving the effect of consonantal direction. Specifically, that process has been proposed to be fluency, such that inward pseudo-words might be more fluently processed (e.g., easier to pronounce) and therefore judged as better names for any kind of object. This alternative explanation is introduced in the following subchapter.

3.2 Fluency

An alternative account for the occurrence of the in-out preference effect has been presented by Bakhtiari et al. (2016): They assumed that the effect might rely on greater processing fluency of inward compared to outward words, rather than a motivational orientation of approach versus avoidance. Processing fluency describes the ease with which the mental operations associated with the processing of a stimulus can be executed; this can relate for example to perception or encoding of the stimulus (for reviews on the concept of fluency, see Alter & Oppenheimer, 2009; Claypool, Mackie & Garcia-Marques, 2015; Reber, Schwarz, & Winkielman, 2004).

3.2.1 Types of Fluency

Alter and Oppenheimer (2009) offer an overview of different types of fluency. Although there has been an abundance of different instantiations of fluency described in the literature, I want to highlight five different categories of fluency in this section. One frequent manipulation to increase processing fluency, namely the repetition of stimuli, shall not be discussed here but in Chapter 4 instead, because of its close link to the concept of familiarity.

Perceptual fluency. The experienced ease or difficulty to perceive a stimulus and the information it conveys is called *perceptual fluency*. The most common manipulations of perceptual fluency focus on the visual perception of stimulus words or pictures: For example, printing text in a clear versus difficult to read font changes the fluency of the text because it is easier to decipher (e.g., Alter, Oppenheimer, Epley, & Eyre, 2007; Novemsky, Dhar, Schwarz, & Simonson, 2007; Oppenheimer, 2006; Simmons, & Nelson, 2006). Another manipulation uses differences in figure-ground contrast, for example by printing text in bright or dark colors or by changing the background color or texture, with higher contrast enabling more fluent processing than lower contrast (e.g., Laham, Alter, & Goodwin, 2009; Reber et al., 1998; Reber & Schwarz, 1999; Silva, Garcia-Marques, & Mello, 2015; Unkelbach, 2006). Apart from altering the visual appearance of a stimulus, perceptual fluency can also be enhanced by simply increasing the duration of stimulus presentation, thereby providing more time to process the stimulus thoroughly (e.g., Winkielman & Cacioppo, 2001). Although most demonstrations of perceptual fluency concentrate on the visual domain, there are also studies which have extended these effects to auditory stimuli (e.g., Bernard, Proust, & Clément, 2014; Besken, & Mulligan, 2014).

Retrieval and encoding fluency. A second type of fluency refers to memory related processes: the retrieval of relevant information from memory, as well as the encoding of novel information in memory (Kelley & Lindsay, 1993; Schwarz et al., 1991; see also Tversky & Kahneman, 1973). For example, Schwarz et al. (1991) demonstrated that the metacognitive ease that is experienced when having to retrieve only a limited amount of information on a certain topic from memory rather than a large amount influences how this information is being judged: When participants had to think of six example situations in which they had shown assertive behavior, they subsequently judged themselves to be more assertive than participants who were asked to recall twelve such behaviors. Although the second group actually thought of more example situations of their own assertive behavior, they used the perceived difficulty of retrieval as a cue that there might not be many such examples and accordingly judged themselves as less assertive (Schwarz et al., 1991). In the opposite direction, the ease of encoding information, for example when learning a new association or building a representation of a stimulus, influences perceived learning success and confidence in later recall of the information (e.g., Castel, McCabe, & Roediger, 2007; Hertzog, Dunlosky, Robinson, & Kidder, 2003).

Conceptual fluency. Apart from perceptual and memory-based fluency instantiations, there are also fluency effects that relate to higher-order cognitive processes. These can involve different types of higher-order cognition, for example spatial processing (e.g., Unkelbach, 2006) or mental imagery (Mandel, Petrova, Cialdini, 2006; Petrova & Cialdini, 2005). The most extensively researched type of fluency in this area, however, is conceptual fluency. This means that the processing of a stimulus is more fluent when related concepts are activated. This is mostly achieved by priming participants with a relevant semantic concept before the presentation of target stimuli, such as single words or passages of text (e.g., Lee & Labroo, 2004; Lanska, Olds, & Westerman, 2014; Reder, 1987; Schwartz & Metcalfe, 1992; Whittlesea, 1993). Operationalizations of conceptual fluency range from single word priming (e.g., Whittelsea, 1993) to the presentation of conceptually related advertisements before product ratings (Lee & Labroo, 2004). Following a similar idea, it has been shown that semantically coherent groups of words are more fluently processed than semantically incoherent groups (Topolinski & Strack, 2009b). The crucial difference between conceptual fluency on the one hand and perceptual and retrieval/encoding fluency on the other hand is that the metacognitive feeling of ease doesn't stem from the physical features of presentation of a stimulus or its availability, but rather from its interpretation and classification.

Linguistic fluency. Although it is often not discussed as a main type of fluency, but rather subsumed under perceptual and conceptual fluency, I want to mention linguistic fluency as a distinct category here because of its relevancy in the context of the in-out preference effect. Linguistic fluency basically describes that verbal stimuli (i.e., words, sentences) can influence ease of processing not only through their semantic meaning, but also through linguistic features. On a more conceptual level, for example, grammatical complexity can influence the ease or difficulty with which a message can be understood, with sentences with a complex syntax being more difficult to process than simply structured sentences (e.g., Lowrey, 1998). Similarly, complex words as opposed to less complex alternatives hinder fluent lexical processing (Oppenheimer, 2006). On a lower processing level, the phonological, or articulatory, fluency refers to the ease or difficulty with which a stimulus word can be pronounced. That easier to pronounce words are more fluently processed has been shown for names of stocks (Alter & Oppenheimer, 2006), food additives and amusement park roller-coasters (Song & Schwarz, 2009), and names of persons (Laham, Koval, & Alter, 2012), among others. Overt articulation was not necessary in any of these studies; the covert simulation of the articulation while silently reading the words seems to be sufficient for the fluency effect to occur. These findings demonstrate that the articulatory structure of a word can by itself influence the ease or difficulty with which that word will be processed, which in turn has important consequences for the appraisal of the word or the denoted object.

Motor fluency. The ease of articulation described above also falls into another type of fluency, namely motor fluency. This type of fluency describes the ease with which a certain motor movement, for example in response to a stimulus, can be performed. Movements with the dominant hand, for instance, are generally more fluently executed than movements with the non-dominant hand, which has influences on people's perception of right and left as positive or negative (e.g., Casasanto, 2009; Casasanto & Chrysikou, 2011), as well as on their memory confidence for information written with their dominant or non-dominant hand (Susser & Mulligan, 2015). Motor fluency effects have been also shown for other lateral hand movements (e.g., Milhau, Brouillet & Brouillet, 2013), such as more or less fluent typing (e.g., Brouillet, Milhau, Brouillet, & Servajean, 2016; Jasmin & Casasanto, 2012). Crucially, the actual movement does not have to be performed for motor fluency effects to occur; simply perceiving an object with certain action affordances is sufficient to trigger simulations of those actions which can involve easy (fluent) or more complex (less fluent) movements (e.g., graspable objects, Brouillet, Ferrier, Grosselin, & Brouillet, 2011; Regenberg, Häfner, & Semin, 2012; or easy vs. difficult to type letter pairs, Yang, Gallo, & Beilock, 2009). Such fluent motor simulations are associated with increased positive affect in comparison to less fluent ones (Cannon, Hayes, & Tipper, 2010). That these motor simulations are indeed responsible for the fluency effects has been shown in a number of studies in which effects of motor fluency on preference and liking were eliminated when participants performed interfering overt movements (e.g., hand movements, Casasanto & Chrysikou, 2011; Leder, Bär, & Topolinski, 2012; eye movements, Topolinski, 2010; whole body movements, Sparenberg, Topolinski, Springer, & Prinz, 2012; and mouth movements, Topolinski, 2012; Topolinski & Strack, 2009a, 2010) and even when participants only kept interfering motor plans active in their mind without any overt action (Beilock & Holt, 2007). The ease of execution of motor movements and simulations therefore constitutes another distinct type of fluency alongside the ease of perceptual, mnemonic, and conceptual processing.

3.2.2 Effects of Fluency

As numerous as the instantiations of fluency are, as multifaceted are their effects. For example, fluency increases confidence in one's knowledge (e.g. Alter et al., 2007; Castel et al., 2007; Hertzog et al., 2003; Kelley & Lindsay, 1993; Reder, 1987). It also influences judgments of the self, such as personal assertiveness (e.g., Schwarz et al. 1991), and of other people's personal attributes, such as their intelligence (Oppenheimer, 2006). Another important consequence of processing fluency is the so called *truth effect*, which describes the phenomenon that people perceive fluently processed information as more credible or true than disfluent information (e.g. Bacon, 1979; Begg, et al., 1992; Reber & Schwarz, 1999; Schwartz, 1982; Silva et al., 2015; Unkelbach, 2007). Further effects of fluency have been shown in judgments of morality (e.g., Laham et al., 2009), risk perception (Song & Schwarz, 2009), economic value (Alter & Oppenheimer, 2006), and on consumer behavior (e.g., Lowrey, 1998; Mandel et al., 2006), among others. Several types of fluency also affect perceived familiarity (e.g., Brouillet et al., 2016; Susser & Mulligan, 2015; Whittlesea, 1993; Yang et al., 2009), which will be discussed in greater detail in Chapter 4.

The most common effect of fluency, however, is that it increases liking (Reber et al., 2004). This affective consequence of fluency has been demonstrated across all types of fluency: It can be elicited by repetition (e.g., Zajonc, 1968), perceptual fluency (e.g., Reber et al., 1998; Winkielman & Cacioppo, 2001), conceptual fluency (e.g. Lee & Labroo, 2004; Topolinski & Strack, 2009b), and motor fluency (e.g., Beilock & Holt, 2007; Brouillet et al., 2011; Leder et al., 2012; Sparenberg et al., 2012) among others. Winkielman and Cacioppo (2001) were able to show that this greater liking is even reflected in facial expression, namely spontaneous activity of the zygomaticus major muscle, which is associated with smiling (see also Cannon et al., 2010). Because the effect of greater liking for fluent compared to disfluent stimuli is so universal, Winkielman, Schwarz, Fazendeiro, and Reber (2003, see also Reber et al., 2004) proposed fluency to be hedonically marked, thereby automatically eliciting positive affect. While it might be true that perceived fluency is intrinsically associated with positive affect, this does not mean that fluency must only have positive consequences. Specifically, Unkelbach and Greifeneder (2013) argued that beyond the mere perception of fluency, its attribution to the stimulus as well as the interpretation of its meaning are two additional necessary steps for fluency effects to occur. This was demonstrated in studies showing that the familiarity and truth effects of fluency could be reversed when a training phase induced reverse correlations and thereby altered associations to disfluent-old and fluent-new (Unkelbach, 2006) or disfluent-true and fluent-false (Unkelbach, 2007), respectively. Similar effects were also obtained when participants were explicitly told that previously presented statements had been false (Unkelbach & Stahl, 2009).

3.2.3 Fluency and the In-Out Preference Effect

Based on the findings on articulation fluency (e.g., Alter & Oppenheimer, 2006; Laham et al., 2012; Song & Schwarz, 2009) and fluency effects on liking (e.g. Reber et al., 1998; Winkielman & Cacioppo, 2001; Zajonc, 1968), Bakhtiari et al. (2016) assumed that the in-out preference effect might rely on a simple fluency explanation, rather than a motivational approach-avoidance orientation. If inward pseudo-words were indeed easier to process than outward pseudo-words, that would support this hypothesis. Although the stimuli in the original Topolinski et al. (2014) paper were only presented visually, a covert simulation of the articulation of the stimuli should nevertheless take place (e.g., Edfeldt, 1960; Hardyck et al., 1966; see also Stroop, 1935). It has been argued that these subvocalizations might even be responsible for certain fluency effects to occur in the first place: For example, the false fame effect (Jacoby, Kelley, Brown, & Jasechko, 1989) was eliminated when participants were eating popcorn during the judgment of the names (Topolinski & Strack, 2010). Similarly, a verbal mere exposure effect seems to be prevented by chewing gum during the evaluation of the stimuli (Topolinski & Strack, 2009a), although this effect failed to replicate in a different study (Westerman, Klin, & Lanska, 2015).

Bakhtiari et al. (2016) therefore tested the processing fluency of inward versus outward pseudo-words from the original study (Topolinski et al., 2014) and were able to show that indeed, reading latencies were shorter for inward than outward stimuli. In addition, participants also subjectively rated inward words to be easier to pronounce than outward words. Therefore, inward consonantal patterns seem to be more fluent to process than outward patterns. This effect could either be due to inward oral movements being generally easier to perform than outward movements, perhaps because voluntary movements of ingestion are better trained than the more seldom and mostly involuntary actions of expectoration, or due to an articulatory training effect (Bakhtiari et al. 2016). If the letter was the case, this should be reflected in a higher frequency of real inward compared to outward words in a given language. Analyses on an English and German word corpus revealed that front consonants occurred significantly more often as the first rather than the last consonant in a word, while back consonants were more often the last rather than the first consonant in a word. Consequently, there seem to be more inward than outward consonantal patterns at least in these two languages, which could entail more efficient pronunciation of inward patterns (Bakhtiari et al., 2016). It is important to note, however, that the corpus analyses were limited to the front and back consonants used in the stimuli by Topolinski et al. (2014), instead of looking at all natural consonantal patters with varying distances (see Topolinski & Boecker, 2016). Also, only first and last positions were assessed, disregarding consonants in between that could alter the pattern. Therefore, this corpus analysis can only be considered as preliminary evidence that requires further study.

Crucially, in a mediation analysis using liking as well as subjective articulation fluency ratings, fluency significantly contributed to the prediction of the in-out preference effect. This mediation was only partial, however; a significant independent in-out preference effect remained that was not explained by fluency (Bakhtiari et al., 2016). In sum, the findings suggest that articulatory fluency does indeed play a role in the emergence of the in-out preference effect, but that there is at least a second mechanism responsible for the effect to occur, which might be based on approach-avoidance motivation.

When comparing the two potential mechanisms underlying the in-out preference effect, namely approach-avoidance motivation versus fluency, there is greater evidence in favor of the fluency rather than the approach-avoidance account. The fluency of inward and outward pseudo-words has been directly tested and shown to mediate the effect of consonantal direction on liking. Although this mediation could not fully explain the in-out preference effect and it is possible that there is an additional meditation by approach-avoidance motivation, there are findings that speak against this explanation, such as the modulation of the effect by objects' oral affordances (Topolinski et al., 2017), which would be more in line with a motor fluency account. Also, the effect seems to be rather general in its applications, affecting liking ratings of nonsense words (Topolinski et al., 2014; Topolinski & Boecker, 2016a) to the same (or even greater) degree as palatability ratings for food (Topolinski & Boecker, 2016b), liking ratings of persons and objects (Topolinski et al., 2014), and purchase intentions and willingness-to-pay for non-edible and even negatively perceived objects (Topolinski et al., 2015). The findings suggesting that inward compared to outward pseudo-words are simply easier to pronounce and therefore more fluently processed (Bakhtiari et al., 2016) provide a more convincing explanation of those various effects.

There is ample research demonstrating effects of fluency on familiarity (e.g., Jacoby & Whitehouse, 1989; Lanska et al., 2014; Rajaram & Geraci, 2000; Whittlesea, 1993) especially with regard to motor fluency (Brouillet et al., 2016; Susser & Mulligan, 2015; Topolinski, 2012; Yang et al., 2009), which is particularly interesting in the context of articulation dynamics I am investigating. These effects will be discussed in more detail in the next chapter. On the other hand, I only found one study showing that approach versus avoidance motivation elicits feelings of familiarity (Rotteveel & Phaf, 2007), and even in this case the authors assumed that the effect was mediated by positive affect, or liking. In the later experiments and studies of the present work which investigate potential driving mechanisms of the in-out familiarity effect, I therefore focus on fluency and liking as potential mediators, rather than approach-avoidance motivation.

Chapter 4 – Familiarity

As outlined in the introduction, I expect that inward versus outward articulatory dynamics do not only differentially affect evaluations of pseudo-words, but that they also influence the perceived familiarity of a stimulus. Familiarity describes a feeling of knowing something from previous experience – be it a person, an object, or a procedure. In recognition memory, familiarity is generally defined as a feeling of knowing while not being able to recall the actual previous encounter (e.g., Brown, & Marsh, 2009; Cleary, 2004; ; Jacoby, 1991; Mandler, 1980). To expound the role of familiarity within the framework of this research, the current chapter provides an overview of the causes and consequences of familiarity identified in previous research.

4.1 Familiarity as a Consequence of Exposure

The feeling that something is familiar to us can be induced by a number of various processes. First of all, repeated exposure of a stimulus increases its familiarity (e.g., Coane et al., 2011), because with every repetition there is a higher chance of remembering the stimulus, even if it is only a diffuse feeling of knowing without the ability to explicitly recall it (familiarity vs. recollection; e.g., Jacoby, 1991; Yonelinas 1994, 1999). This type of *true* familiarity is therefore a valid feeling as a consequence of actual previous exposure. One of the most well-known effects of repeated exposure is the *mere exposure effect* (Zajonc, 1968): Zajonc found that when a stimulus is simply presented repeatedly, the attitude towards that stimulus changes in the sense that people begin to like it more. The idea behind this effect is that every presentation strengthens representations of the stimulus in memory. Even when the previous encounter is not consciously remembered, this leads to familiarity and a more fluent processing of the stimulus, which is associated with positive affect (e.g., Bornstein & D'Agostino, 1992). Zajonc and colleagues claimed that the effect of repeated exposure on liking would be direct, without any mediating influence of familiarity, because conscious stimulus recognition is not necessary for the effect to occur (Kunst-Wilson & Zajonc, 1980;

Moreland & Zajonc, 1977; 1979; Zajonc, 1980, 1984). This view has been challenged, however, based on the argument that a failure in consciously distinguishing between old and new items in a recognition test does not necessarily mean that there is no underlying process of familiarity and/or fluency, especially when uncertainty his high (Birnbaum & Mellers, 1979a; 1979b; Birnbaum, 1981). Research suggests that the mere exposure effect seems to be based on implicit memory (Seamon et al., 1995). The implicit learning of a stimulus should increase processing fluency and reduce uncertainty, which increases liking because people generally prefer predictable, familiar stimuli (Lee, 2001; see also Reber et al., 1998). This affective response is even reflected in higher zygomaticus major activity towards familiar stimuli (Harmon-Jones & Allen, 2001). Taken together, the different studies on the mere exposure effect suggest that both direct influences of fluency and implicit memory as well as indirect influences of perceived familiarity play a role in the increased liking of repeated stimuli (e.g., Lee, 2001). But why is a feeling of familiarity even affectively charged?

The theory is that when something feels familiar without being able to recall the specifics of a previous experience with it, from an evolutionary perspective this is a sign that the experience was positive or neutral, and that the object or person is therefore safe (e.g., Bornstein, 1989; Bornstein, Leone, Galley, 1987; Hill, 1978). This is in line with research showing that negative experiences can in many domains be more diagnostic, and are therefore often better remembered (Robinson-Riegler & Winton, 1996; Skowronski & Carlston, 1987, 1989; for a review on the negativity bias, see Rozin & Royzman, 2001). To give an example, the experience of getting sick once after eating a certain type of food is often enough to evoke a strong and long-lasting aversion to that food because this aversion protects the organism from consuming a potentially toxic substance again (Garb & Stunkard, 1974; Seligman, 1970; see also Garcia & Koelling, 1966). Based on this explanation and a processing fluency account, familiarity is used as a cue not only to infer a stimulus' likability (e.g., Lee, 2001), but also its truth (e.g., Bacon, 1979; Begg et al., 1992; Garcia-Marques, Silva, Reber, & Unkelbach, 2015; Moons et al., 2009; Schwartz, 1982), trustworthiness (e.g., Zebrowitz, Bronstad, & Lee, 2007), and safety (e.g., Litt et al., 2011). Interestingly, the familiarity of a stimulus elicited by repeated exposure has also been shown to affect behavioral outcomes of approach versus avoidance (Jones, Young, & Claypool, 2011): Participants were faster to respond with an approach movement and slower to respond with an avoidance movement to familiar compared to novel target stimuli. Also, when participants were allowed to freely choose their response toward different target stimuli, some of which were familiar and some were novel, they more often chose approach movements in response to familiar target stimuli than in response to novel target stimuli.

The effects of familiarity through repeated exposure have been and still are of great interest for researchers in the domain of advertising and consumer behavior. To make potential consumers familiar with a brand or product and to positively influence their attitude thereof is the core objective of marketing and advertising. To this effect, studies have shown that repeated presentation of brand and product information, for example in advertisements, indeed leads to increased liking of the respective brand or product (e.g. Hansen & Wänke, 2009; Hekkert, Thurgood, & Whitfield, 2013; Janiszewski, 1993). Also, it influences memory for advertised brands (e.g., Krishnan & Shapiro, 1996; for a meta-analytic overview of memory and attitude effects of repeated advertising, see Schmidt & Eisend, 2015). Familiarity does not only influence the liking of the advertised brand or product, but it also increases the perceived credibility of the content of the advertisement itself (Roggeveen & Johar, 2002), in line with the truth effect described earlier in the context of processing fluency. Crucially, the effects of familiarity are not limited to mere evaluations, but also affect actual consumer behavior, for instance in the form of brand choice (e.g., Baker, 1999) or choice of music (Ward, Goodman, & Irwin, 2014), with the latter effect even going against consumers' own expectations, who erroneously believe they would prefer to listen to unfamiliar music, but then choose the familiar music instead. In sum, these findings underline the great potential of familiarity effects in the marketing and consumer research domain.

4.2 Illusion of Familiarity

Independent of the actual familiarity elicited by previous encounter and/or experience with a stimulus, other factors can trigger an illusory, *false* familiarity (see Schacter & Slotnick, 2004, for the neural correlates of false versus true recognition). An example for such an impression of previous encounter that objectively never occurred is the déjà vu phenomenon (Brown, 2003; 2004; Cleary, 2008); the feeling of re-living a past situation that actually has never happened, potentially because the situation is highly similar to a different previous event (Cleary et al., 2009). Apart from similarity, other psychological processes can induce illusory familiarity, for example the perceptual or conceptual fluency of the stimulus at hand (e.g., Jacoby & Whitehouse, 1989; Johnston et al., 1985; Rajaram & Geraci, 2000; Whittlesea, 1993). Because the repeated presentation of a stimulus increases the fluency with which it is processed, as described in the subchapter above, novel stimuli that are fluently processed due to external influences such as features of their visual presentation or prior semantic priming can be interpreted as having been previously encountered. Johnston et al. (1985) as well as Whittlesea et al. (1990), for example, manipulated the visual clarity of target words in a recognition memory test, showing that higher visual clarity – and therefore, higher perceptual fluency – more often led participants to judge targets as having been presented during a prior study phase. Similar effects were yielded by enhancing conceptual fluency through the brief presentation of a context word before the target (Jacoby & Whitehouse, 1989) or through embedding the target word at the end of a sentence that created matching semantic expectations (Whittlesea, 1993; see also Lanska et al., 2014, for a comparison of perceptual and conceptual fluency effects on illusions of familiarity). Perceived familiarity can also be evoked by motor fluency (e.g., Brouillet et al., 2016; Susser & Mulligan, 2015; see also Topolinski, 2012): For example, easy to type letter pairs were more often judged to be old compared to difficult to type pairs, irrespective of whether they had actually been previously presented or not (Yang et al., 2009). When processing fluency affects the perceived familiarity of a novel stimulus, this effect can be regarded as an *illusion of familiarity* (Whittlesea, 1993), given that a novel stimulus which is encountered for the first time cannot truly be familiar in the literal sense of the word; it can, however, evoke cognitive feelings that may falsely be attributed to and interpreted as familiarity.

Following a similar process, general positivity or liking of a stimulus can on its own create false feelings of familiarity (e.g., Garcia-Marques et al., 2004; Monin, 2003; Phaf & Rotteveel, 2005). In the opposite direction as in the mere exposure effect, where repeated exposure leads to liking (Zajonc, 1968), positivity is used here as a heuristic to infer prior exposure to the stimulus (Garcia-Marques et al., 2004; Monin, 2003). This effect occurs for pictures of faces differing in attractiveness, but also for simple word stimuli with positive versus negative valence. Monin (2003), for example, presented student participants with pictures of faces differing in attractiveness, half of which allegedly belonged to people on campus, and asked participants to rate how familiar they seemed to them. The results demonstrated that attractive faces were judged as being more familiar; an effect that could not be explained solely by the prototypicality of the faces, as had been previously assumed (e.g., Langlois, Roggman, & Musselman, 1994). That it was indeed the positive valence of the attractive faces that drove the effect was demonstrated in follow-up experiments by Monin: On the one hand, effects of greater or lower familiarity could be achieved with the exact same moderately attractive pictures when these were framed as either attractive or unattractive by the presentation of a more extreme comparison standard. One the other hand, when participants were presented with positive and negative words and were led to believe that some of these words had been subliminally presented to them before, they judged the positive words as being old more often than the negative words. In line with these results, Garcia-Marques and colleagues (2004) found that smiling faces were judged as old more often than neutral faces in a recognition test, independent of whether they had actually been presented or not. Also, subliminally priming neutral words with a smiley rather than a neutral circle in the test phase of a recognition task led to higher old ratings of those primed words.

The process behind these effects can be described as a (mis)attribution of positivity to familiarity (Claypool, Hall, Mackie, & Garcia-Marques, 2008; Corneille, Monin, & Pleyers, 2005): As a default, the positive affect is attributed to the stimulus itself and interpreted as a cue that the stimulus was encountered before. When a different source of the affect is apparent, such a misattribution does not take place. This is supported by the finding that positive mood induced by reading a happy story increased the perceived familiarity of subsequently presented stimuli, but only if participants were not made aware of the fact that the story had elicited their good mood (Claypool et al., 2008). Rotteveel and Phaf (2007) were able to extend the findings on illusions of familiarity to stimuli that were not inherently valenced, though: They presented affectively neutral target words on screen first in a study phase and later again in a text phase, then intermixed with novel words. In the test phase, the words were presented in a way that their size was progressively enlarged or diminished, thereby creating the impression of a movement towards or away from the perceiver. In line with the association of such movements with the concepts of approach and avoidance, participants more often judged the increasing (i.e., approaching) target words as being old than the decreasing words, independent of whether a word had actually been presented before or not. Rotteveel and Phaf (2007) claim that this effect can be explained via positive affect: They enunciate the idea that the approach (avoidance) movements are inherently associated with positive (negative) affect, and that this elicited affect is then misattributed and interpreted as familiarity of the target. From the previously described research on approach-avoidance, however, a motivational explanation of the finding might be equally conceivable.

Taken together, the effects of familiarity on perceived positivity as well as of positivity on perceived familiarity suggest that the link between positivity and familiarity is bidirectional, which is also supported by the finding of mutual response facilitation (i.e., positive stimuli facilitating responses of familiarity, familiar stimuli facilitating responses of positivity; Garcia-Marques, Mackie, Claypool, & Garcia-Marques, 2010). In addition, various types of fluency can elicit illusions of familiarity, such as perceptual, conceptual, and motor fluency. Both fluency and liking shall therefore be considered as possible mediators of the potential in-out familiarity effect that is to be investigated in the present work.

Chapter 5 – Outline of Experiments and Analyses

As outlined in the introduction, the aim of the present work is to test the effects of consonantal direction on perceived familiarity. I predominantly investigate this via various recognition paradigms. In such paradigms, participants are first presented with a number of stimuli in a study phase. After a delay of varying duration, the same stimuli are again presented in a test phase, but intermixed with new stimuli. Participants' task is to indicate for each stimulus whether it is old or new. Correct classifications of stimuli presented in the prior study phase are considered *hits*. When new stimuli are falsely considered as old, on the other hand, these trials are called *false alarms*. Generally speaking, when old and new stimuli can be distinguished well, they should produce high hit rates and low false alarm rates. High illusory familiarity for a certain type of stimuli, in contrast, should be reflected in both more frequent hits *and* false alarms for that type of stimuli (see Banks, 1970).

5.1 Experiments and Hypotheses

As a first test of the proposed effect, Experiment 1 will employ a classical recognition task with consonantal inward and outward pseudo-words being presented in a study phase before later being intermixed with novel stimuli of the same kind in a test phase. Participants will be instructed to classify the stimuli in the test phase as either old or new via key press. Based on previous findings of greater liking and fluency for inward compared to outward pseudo-words, my hypothesis is that inward-pseudo words will be judged as being old more often, leading to both higher hit rates and higher false alarm rates in comparison to outward pseudo-words. In an approach based on *signal detection theory* (SDT; see Banks, 1970; Green & Swets, 1966), the hypothesized effect should be apparent in a significant difference in response bias between inward and outward pseudo-words, with inward stimuli showing a more liberal response criterion, whereas there should be no difference with regard to discriminability between the two consonantal directions.

Since the introduction outlined the potential advantages of an application of this effect in a marketing context, Experiment 2 will test the robustness of the effect in such a setting:

Inward and outward pseudo-words will be presented as product names in a recognition task similar to Experiment 1, accompanied by different product pictures. The hypothesis is that the effect is strong enough to persist alongside product pictures, again leading to higher hit and false alarm rates for inward compared to outward pseudo-words. Experiments 3a and 3b will test whether the effect translates to direct ratings of familiarity. To test this, the inward and outward pseudo-words will be presented as brand names and participants will be asked to rate these brands for their familiarity on a scale from 0 to 10. It is expected that inward brand names will also be explicitly rated as more familiar than outward brand names. Experiment 3b will offer a replication of this effect on a different set of stimuli and a different type of brands, with the hypothesis that the same effect should emerge as in Experiment 3a.

Ruling out a possible alternative explanation of a mere affirmation tendency towards stimuli with an inward compared to an outward consonantal direction, Experiment 4 will employ an altered version of the recognition task of Experiment 1, using a Go/No-go paradigm (Donders, 1868/1969). In this paradigm, participants will be divided into two groups, with one group being instructed to identify all old stimuli via key press and the other to identify all new stimuli via key press, while not reacting to the other stimuli. The hypothesis is that if the effect is indeed based on higher perceived familiarity of inward pseudo-words, those inward pseudo-words will receive fewer responses than outward pseudo-words in the identify-new condition, thereby contradicting a general affirmation tendency.

While I assume that consonantal direction only influences perceived familiarity of a stimulus, but not participants' ability to recollect that stimulus - which I expect to be supported by the SDT based results in Experiments 1, 2 and 4 - this claim needs further experimental validation. Therefore, Experiments 5 and 6 will seek to separate effects of consonantal direction on familiarity from those on recollection. Experiment 5 will introduce additional instructions to a recognition task asking participants to only respond *old* to a stimulus if they specifically remember having encountered it in the study phase, a manipulation that should eliminate familiarity effects. It is expected that in this experimental setting, no differences in hits or false alarm rates should be found between inward and outward pseudo-words anymore because they do not differ with regard to recollection. For a more elaborate assessment, Experiment 6 will involve a *process dissociation procedure* (PDP, Jacoby, 1991) designed to separate familiarity from recollection in a recognition task. Following this procedure, inward and outward pseudo-words will be presented to participants in the study phase in two separate lists of different color. In the test phase, participants will be either instructed to respond *old* to any stimulus that appeared in either list, or they will be asked to only respond *old* to the stimuli of one of the two lists, but not the other. All participants will complete a study and test phase each under these instructions. From the performance in this inclusion and exclusion condition it is possible to calculate a familiarity and recollection score. My hypothesis is that while the familiarity score will be significantly higher for inward compared to outward pseudo-words, there will be no difference in recollection between the two consonantal directions.

Finally, I want to address the potential mechanism underlying the in-out familiarity effect. One possibility is that articulatory fluency is responsible for the effect, as outlined in Chapter 3. If this is the case, I expect that inward pseudo-words will be rated higher on subjective articulatory fluency than outward pseudo-words (as it was found for a different set of stimuli by Bakhtiari et al., 2016), which will be tested in Experiment 7. Another possibility is that the greater liking for inward over outward pseudo-words previously found in the literature (e.g., Topolinski et al., 2014) is driving the effect of consonantal direction on familiarity. This liking might itself be evoked by fluency (see Bakhtiari et al., 2016), but it might also elicit an effect on familiarity independent of fluency, which would indicate a separate mechanism possibly linked to approach-avoidance motivation. The respective role of fluency and liking in the in-out familiarity effect shall be tested in an exploratory correlation analysis in Study 8 which will investigate the interrelation between the results from the conducted experiments and fluency and liking ratings. Subsequent mediation analyses will test whether liking, fluency or both mediate the effect of consonantal direction on familiarity. Experiment 9 and Study 10 will provide replications of Experiment 7 and Study 8 using the other set of stimuli introduced in Experiment 3b. I expect these analyses to shed light on the potential mechanisms underlying the in-out familiarity effect, thereby providing new insights into the nature of this effect, its potential applications and boundary conditions.

5.2 Sample Sizes and Analysis Methods

As an estimate of the expected effect size, I used the mean of the effect sizes obtained in Experiments 1a and 1b in Topolinski & Boecker (2016a) that are based on the same stimulus pool that I am using in my experiments, which was $d_z = 0.48$. Based on *G*Power*, the required sample size to gain such an effect in a two-sided paired samples *t*-test with a power of 0.95 is $N = 59$. However, since I was testing for familiarity instead of liking, I wanted to be sure that also weaker effects were detected and therefore decided to generally over-power the present experiments. This was especially true for Experiment 6 involving a process dissociation procedure in which I was testing for an interaction effect; here I decided to run N = 200 participants at minimum. Due to logistical factors (participant flow, required sample sizes for other tasks also running in the experimental session), sample sizes varied slightly across the experiments. Statistical analyses were computed after data of the full sample was collected. I report all IVs, DVs, and data exclusions.

Analyses were computed using both SPSS and R (R Core Team, 2016). Specifically, mixed and repeated measures ANOVAs as well as *t*-tests were run in SPSS, while all *linear mixed model* (LMM) and *generalized linear mixed model* (GLMM) analyses with subjects and items as random factors were run in R using the *lmer* and *glmer* functions of the *lme4* package, respectively (version 1.1-12; Bates, Mächler, Bolker, & Walker, 2015, 2016) as well as the *mixed* function in the *afex* package (version 0.16-1; Singmann, Bolker, Westfall, & Aust, 2016). In addition, Bayesian ANOVAs and *t*-tests were conducted in R using the *BayesFactor* package (version 0.9.12-2; Morey, & Rouder, & Jamil, 2015) and JASP (JASP Team, 2016) to ensure reliability of effects beyond the conventional methods of significance testing (e.g., Goodman, 1999; Wagenmakers, Morey, & Lee, 2016). For Bayesian *t*-tests, the default Cauchy prior with a scale parameter of $r = 0.707$ ($\sqrt{2}/2$) recommended in the literature (Rouder, Speckman, Sun, Morey, & Iverson, 2009) was employed, while for Bayesian ANOVAs, I used the recommended default prior with a scale parameter of $r = 0.5$ (Rouder, Morey, Speckman, & Province, 2012; Rouder, Morey, Verhagen, Swagman, & Wagenmakers, 2016). I generally report BF_{10}, which is the likelihood that the data is observed under the alternative hypothesis (H_1) in comparison to the null hypothesis (H_0): A BF_{10} of 15, for example, means that the data is 15 times more likely to be observed under H_1. The likelihood that the data occurred under the null hypothesis can be simply calculated from that value by $1/ BF_{10} = BF_{01}$. A BF_{10} of 1 would therefore signify equal likelihood for H_1 and H_0, and consequently offer no evidence for either hypothesis. In terms of the interpretation of Bayes Factors, values for BF_{10} from 1 to 3 are generally considered as only anecdotal, values from 3 to 10 as moderate, from 10 to 30 as strong, from 30 to 100 as very strong, and above 100 as extremely strong/ decisive evidence for H_1 (e.g., Jeffreys, 1961; Lee, & Wagenmakers, 2013; cf. Kass, & Raftery, 1995). Note that in Bayesian ANOVAs, the likelihood of a model with several effects can become extremely high in comparison to the likelihood of a null model with no effects, resulting in very large Bayes Factors. In these cases, I use scientific notation and report values of 3,200,000 as 3.2×10^6, for example.

Chapter 6 – Articulation Dynamics and Recognition Memory

In the first experiment to test the potential influence of consonantal inward or outward direction on familiarity, a classical recognition task was employed, using inward and outward pseudo-words from a previous publication (Topolinski & Boecker, 2016a). If inward consonantal direction should indeed lead to higher perceived familiarity than outward consonantal direction, I expect inward pseudo-words to elicit more frequent hits and false alarms compared to outward pseudo-words.

6.1 Experiment 1

Using a recognition paradigm, I wanted to test whether inward pseudo-words would elicit higher hits and false alarm rates than outward pseudo-words. Such forced-choice item-recognition tests (Murdock, 1974; Ratcliff, 1978; Ratcliff & Murdock, 1976) have been and still are widely used in research on memory effects (e.g., Montefinese, Zannino, & Ambrosini, 2015; Westerman, 2008), with various adaptations (e.g., *remember/know*; Gardiner 1988; Tulving 1985). While actual familiarity through previous exposure should only improve hit rates, false familiarity due to consonantal direction should increase both hits and false alarms (see Dobbins, Khoe, Yonelinas, & Kroll, 2000). Similarly, Johnston et al. (1985) as well as Whittlesea et al. (1990) demonstrated that false familiarity induced by perceptual fluency manipulations led to higher false alarms in this classic item-recognition paradigm (see also Jacoby & Dallas, 1981), an effect that has been shown to extend to manipulations of conceptual fluency (Jacoby and Whitehouse, 1989; Whittlesea, 1993).

6.1.1 Method

Participants. $N = 109$ German speaking university students participated in the study. Four participants were excluded because they did not complete the experiment, resulting in a final sample of $N = 105$ participants (70 female, 35 male, mean age 22, $SD = 5$).

Materials. I used the artificial two-syllable pseudo-words from Topolinski and Boecker (2016a) as inward and outward stimuli because they provide a strong inward-outward manipulation by only featuring one front and one back consonant each (e.g., EMOK, inward; OKIP, outward; see Appendix A for the full stimulus list). The front consonants used in these stimuli were B, M, and P; the back consonants used were G, K, and R, based on

German phonation. In addition, the stimuli control for vowel wanderings, making it possible to assess the impact of consonantal direction independent of vowel direction. In German phonation, I and E are front vowels, while U and O are back vowels. Because the vowel A does not strictly belong to either of these categories, it was not used in these stimuli. Vowel wanderings had no clear effects on preference in a recent study by Topolinski and Boecker (2016a) and are not hypothesized to show an effect in the current study, but since this study is investigating a novel familiarity effect, I wanted to be able to gauge this potential additional factor. By combining the direction of consonant and vowel articulation, the stimuli can be categorized into four groups: a) consonantal in – vocal in, b) consonantal in – vocal out, c) consonantal out – vocal in, d) consonantal out – vocal out. An important characteristic of the stimuli is that the pseudo-words in these four groups consist of the same letter combinations, as described above, simply in different order. Therefore, confounding effects of general letter frequency in the German language can be ruled out. Letter combinations that resulted in actual German words (such as OBER, which means waiter) were excluded. This led to a sample of 142 stimuli in total, with 34 to 36 stimuli in each of the aforementioned four categories. Stimuli were divided into four lists of 36 pseudo-words each, consisting of 9 stimuli from each category (2 stimuli were used twice here to achieve an even number of items in the experiment).

Procedure. The experimental procedure was divided into a study phase and a test phase. In the study phase, one of the lists of stimuli was presented to the participants with the instruction to simply read the pseudo-words. The stimuli were presented sequentially for 1000 ms each, followed by an inter-stimulus interval of 500 ms. Which list appeared in the study phase was counterbalanced across participants. After a delay of approximately 3 minutes during which participants completed an unrelated task for another project, the test phase followed. Participants were presented with the stimuli from the previously shown list, randomly mixed with stimuli from a second, novel list. They were asked to indicate for each stimulus whether it had been presented before and would therefore be considered old or whether it appeared for the first time and would consequently be categorized as new by pressing an assigned key. Figure 3 provides a schematic graphical representation of the experimental procedure. The experiment took approximately 10 minutes to complete.

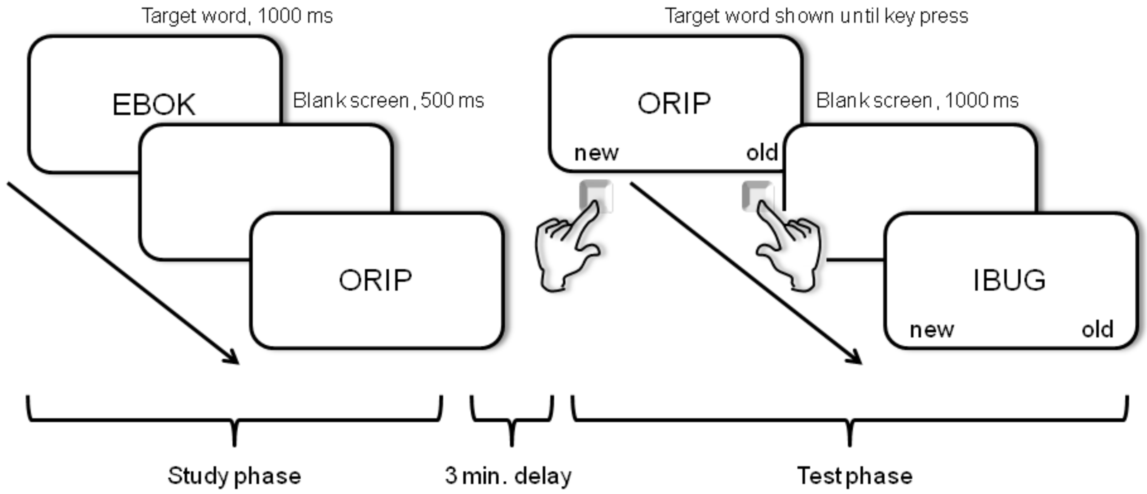


Figure 3: Schematic illustration of the experimental procedure of Experiment 1.

6.1.2 Results

A 2 (Exposure status: old, new; within) X 2 (Consonantal direction: in, out; within) X 2 (Vocal direction: in, out; within) repeated measures ANOVA was conducted on the likelihood of a pseudo-word being perceived as old. I found a significant main effect of exposure status, $F(1, 104) = 14.53$, $p < .001$, $\eta_p^2 = .12$, with previously presented items being categorized as old more often ($M_{old} = .64$, $SE = .02$) than new items ($M_{new} = .60$, $SE = .01$). More importantly, the analysis also revealed a significant main effect of consonantal direction, $F(1, 104) = 31.01$, $p < .001$, $\eta_p^2 = .23$, with inward pseudo-words being categorized as old more often ($M_{in} = .66$, $SE = .02$) than outward pseudo-words ($M_{out} = .58$, $SE = .02$). There was no significant interaction between these two factors, $F(1, 104) = 0.47$, $p = .493$, and no main effect or two-way interaction of vocal direction, all $Fs \leq 1.59$, all $ps \geq .210$. There was also a small, but non-significant three-way interaction of exposure status, consonantal direction, and vocal direction, $F(1, 104) = 3.46$, $p = .066$, $\eta_p^2 = .03$. This was simply due to the fact that the difference between consonantal inward and outward pseudo-words was slightly larger for new vocally inward than new vocally outward target stimuli, while there was no difference between the effects when comparing old vocally inward and old vocally outward stimuli[1]. A Bayesian Repeated Measures ANOVA confirmed these results,

[1] The size of the effect of consonantal direction differed between new vocally inward and new vocally outward stimuli, t(104) = 2.29, 95% CIdifference [0.01, 0.12], p = .024, but not between old vocally inward and old vocally outward stimuli, t(104) = -0.37, 95% CIdifference [-0.08, 0.06], p = .715. Even the smallest pair-wise comparison between consonantal inward and outward pseudo-words, however, namely for new vocally outward stimuli, was still significant, t(104) = 2.58, 95% CIdifference [0.01, 0.09], p = .011, dz = 0.25.

with the model including only the two main effects of exposure status and consonantal direction having the highest Bayes Factor, $BF_{10} = 6.02 \times 10^{10}$. Since I did not find a main effect of vocal direction or interaction with any other variable (respective Bayes Factors were clearly below 1, all $BF_{\text{Inclusion}} \leq 0.054$), which fits with the results by Topolinski & Boecker (2016a), I excluded vocal direction from all following analyses. Figure 4 illustrates the main effects of exposure status and consonantal direction.

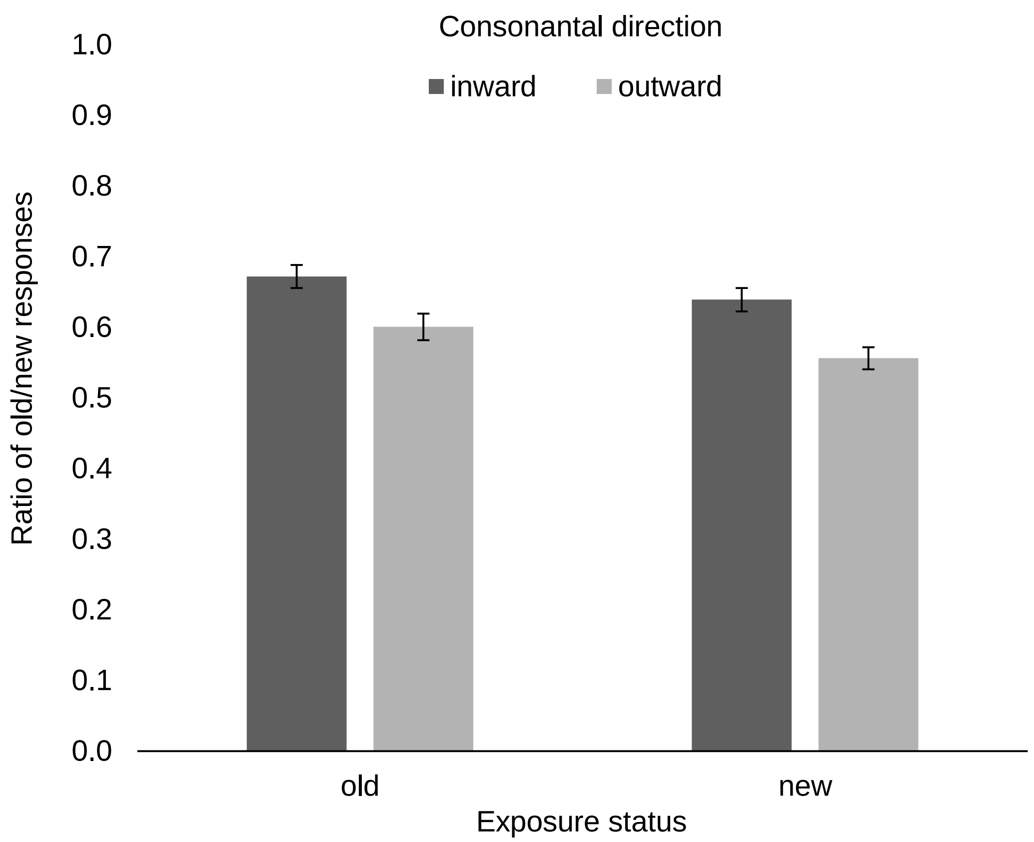


Figure 4: Mean ratios of old/new responses for inward and outward pseudo-words by exposure status (error bars are *SEM*s); bars labeled "old" represent hits, bars labeled "new" represent false alarm rates.

Analyzing the data on an item rather than subject level confirmed the previously found effects: A 2 (Exposure status: old, new; within) X 2 (Consonantal direction: in, out; between) mixed ANOVA again found a significant effect of consonantal direction, $F(1, 140) = 20.10$, $p < .001$, $\eta_p^2 = .13$, as well as exposure status, $F(1, 140) = 9.88$, $p = .002$, $\eta_p^2 = .07$, but no interaction of the two factors, $F(1, 140) = 0.44$, $p = .506$. The model including only the two main effects without an interaction again also had the highest Bayes Factor, $BF_{10} = 958.99$.

Clark (1973) suggested this type of item analysis for studies using linguistic stimuli because such stimuli can always only be regarded as a sample of the vast number of words in a language (or letter combinations in the case of pseudo-words I test here). Therefore, an item analysis should be conducted to exclude the possibility that random differences between items are actually driving an effect attributed to another factor.

However, the aggregation of trials for the item analysis then again ignores differences between participants. A useful way to take both participants and items into account at the same time is to run a multilevel model on the trial level with participants and items as crossed random factors (Quené & van den Bergh, 2008; see also Judd, Westfall, & Kenny, 2012). In the case of the recognition task in this experiment the response variable was binomial on the trial level (old =1 vs. new = 0); therefore, a *generalized linear mixed model* (GLMM; e.g., Breslow & Clayton, 1993; see also Quené & van den Berg, 2008) was required here that follows the principles of a logistic regression. The GLMM analysis consequently gives out logit values as estimates of fixed effects, which I here exponentiated to better interpretable *odds ratios* (*OR*). Chi-square values and corresponding p-values are based on *likelihood ratio tests* (LRT) comparing models with versus without the parameter in question. The model included exposure status (contrast coded: old = 0.5, new = -0.5) and consonantal direction (contrast coded: in = 0.5, out = -0.5) as well as their interaction as fixed effects, with items and subjects as crossed random factors. Intercepts were allowed to vary randomly across both items and subjects. Slopes for the effect of consonantal direction were allowed to vary randomly across subjects. When any random slopes for the effect of exposure status were included, the model failed to converge; consequently, random slopes for the effect of exposure status were excluded from the final model (procedure recommended by Barr, Levy, Scheepers, & Tily, 2013). Again, I found significant main effects for both exposure status, $\chi^2(1) = 13.57$, $p < .001$, $OR = 1.20$, 95% CI_{OR} [1.09, 1.33], and consonantal direction, $\chi^2(1) = 15.69$, $p < .001$, $OR = 1.47$, 95% CI_{OR} [1.22, 1.77]. There again was no interaction effect between consonantal direction and exposure status, $\chi^2(1) = 0.18$, $p = .674$, $OR = 0.96$, 95% CI_{OR} [0.79, 1.17]. Variances of random effects are displayed in Appendix B.

As a final analysis, I wanted to test whether inward pseudo-words truly elicit higher familiarity than outward pseudo-words, in opposition to having an actual memory advantage in the way that inward pseudo-words might be easier to recollect than outward pseudo-words. Although the lack of any interaction of consonantal direction with exposure status already shows that consonantal direction affected both hits and false alarm rates (see Figure 4), I conducted a signal-detection-theory-based analysis (SDT; see Banks, 1970; Green & Swets, 1966), calculating discriminability (*d-prime*) and the criterion (or response bias, *C*) for inward and outward pseudo-words separately for each participant (Snodgrass & Corwin, 1988; Stanislaw & Todorov, 1999)[2]. Two paired-samples *t*-tests revealed a significant difference in *C* between inward and outward pseudo-words $M_{\text{difference\_C-in\_C-out}}$= -0.22, $t(104) = -4.52$, 95% $\text{CI}_{\text{difference}}$ [-0.33, -0.13], $p < .001$, $d_z = -0.44$, $BF_{10} = 962.92$, indicating a more liberal criterion for inward compared to outward pseudo-words. In other words, there was an overall greater bias to categorize inward pseudo-words as old. There was, however, no significant difference in *d-prime*, $t(104) = -0.39$, $p = .696$, $BF_{10} = 0.12$, meaning the data did not show a difference in discriminability between inward and outward pseudo-words.

6.1.3 Discussion

As predicted, participants categorized inward pseudo-words as being old more frequently than outward pseudo-words, and this was true for both previously presented and new pseudo-words. This means that there were not only more hits but also more false alarms for inward pseudo-words, which speaks against better discriminability and for a more liberal response bias for inward compared to outward pseudo-words, as confirmed by the signal detection analysis. Therefore, the findings lend support to the hypothesis that inward pseudo-words evoke stronger feelings of familiarity than outward pseudo-words.

Chapter 7 – Robustness of the Effect: Competing Information and Subjective Ratings

The results of Experiment 1 demonstrate that a simple manipulation of consonantal direction is sufficient to increase feelings of familiarity for pseudo-words in a recognition test. While it is interesting to see that consonantal direction can elicit this effect, one might wonder how robust this effect is in the presence of other information. For example, additional visual information in the form of pictures could provide much more salient cues in a recognition test and therefore override any effects of consonantal direction. In research on the in-out preference effect, Topolinski and Boecker (2016b) showed that when presenting inward and outward pseudo-words as names of food items with accompanying pictures, items with inward names were rated as more palatable than items with outward names (Experiment 3),

[2] In the seldom cases where hit or false alarm rates were 0 or 1, these values were replaced with 0.001 and 0.999, respectively. No negative values of *d-prime* occurred.

but this effect disappeared when food pictures themselves contained information about possible palatability (Experiment 2). Similar to these findings, it is possible that the in-out familiarity effect I found in Experiment 1 will not persist when pictures are available, because people generally have an excellent memory for pictures (e.g., Standing, Conezio, & Haber, 1970) and therefore might concentrate their recognition judgments on the pictures entirely. If the effect is robust, however, it should remain significant even when competing visual information is available, which was tested in Experiment 2.

Another question regarding the effect of consonantal direction on familiarity is whether people would not only judge inward pseudo-words as old more frequently than outward pseudo-words, but also explicitly report higher feelings of familiarity for inward compared to outward pseudo-words. In the recognition paradigm in Experiment 1, participants seemed to misattribute their feelings of familiarity towards inward rather than outward stimuli to previous exposure in a study phase. It is possible that no familiarity effect would be found outside such a recognition paradigm, when participants would directly be asked to rate inward and outward pseudo-words for their familiarity. I hypothesize in contrast that the influence of consonantal direction is strong enough to also affect subjective ratings of familiarity in the absence of a prior exposure phase, which will be tested in Experiments 3a and 3b.

7.1 Experiment 2

To investigate whether the effect of consonantal direction would remain robust in the presence of competing visual information, the inward and outward pseudo-words from the first experiment were paired with pictures in Experiment 2. A comprehensible context for such word-picture pairings was achieved by presenting the in- and outward pseudo-words as names of different products which are visualized in the presented pictures. This framing also provided the interesting opportunity to assess the potential applicability of the in-out familiarity effect: As it was outlined in subchapter 2.2 on sound symbolism, the informed design of brand and product names offers great potential to strengthen marketing strategies and to boost advertising impact effectively and efficiently. Evoking familiarity of brands simply by employing the effects of consonantal direction in the design of brand names would therefore be an elegant strategy to improve advertising success. However, unless advertisements are created for radio transmission, where only auditory information is available, brand and product names are almost always accompanied by pictures, both in TV or print advertisements and on product packages. These pictures are used because they provide salient, easily recognizable cues that help to create associations with a brand or product and increase their memorability (i.e., pictures are remembered better than words; e.g., Grady, McIntosh, Rajah, & Craik, 1998; Shepard, 1967; Standing et al., 1970). At the same time, this high salience of pictures might override the familiarity effect created by the subtle manipulation of consonantal direction. Experiment 2 therefore tested whether the in-out familiarity effect remains robust in a recognition task when competing cues in the form of product pictures were present.

7.1.1 Method

Participants. *N* = 117 German speaking university students participated in the study. Four participants were excluded because of incomplete responses, resulting in a final sample of *N* = 113 participants (67 female, 46 male, mean age 24, *SD* = 3).

Materials. Pictures of three food product categories were sampled for the current experiment. Specifically, I used pictures of cheeses, chocolates, and gummy bears. I chose these categories because a) many different brands offer these kinds of products with different names, which makes the setup more realistic, and b) it is possible to find a number of different pictures for the product categories that are, at the same time, not so dissimilar as to make a memory test non-diagnostic (note that picture memory is in general very accurate, see for example Standing et al., 1970). I sampled 72 pictures in total (24 for each product category) and divided them into two lists of 36 pictures. Figure 5 shows example stimuli from the three different product categories. As verbal stimuli, I used the same stimuli as in Experiment 1.

Figure 5: Example stimuli for the three product categories in Experiment 2.

Procedure. The recognition task required a study phase as well as a test phase. For the study phase, the 36 pictures from one of the two lists were randomly paired with the pseudo-word stimuli from one of the four lists. In each trial, the pseudo-word stimulus appeared first for 1000 ms, then the picture appeared right above the pseudo-word and both stimuli were visible together for another 1000 ms. I implemented this short delay in the presentation of the picture to ensure that participants would read the pseudo-word instead of only looking at the picture. Instructions for the study phase told participants that they would now see a number of products and their names, and that they should simply look at the product pictures and read the names. In the following test phase, participants were informed that they would now see the same products and their names again, but mixed with new products, and that their task would be to indicate via key press whether each product and their name had been presented before ("OLD") or was presented for the first time ("NEW"). Therefore, the same parings of pseudo-words and pictures from the study phase were presented again, mixed with new stimulus pairings consisting of pictures from the other product picture list combined with pseudo-words from one of the four remaining pseudo-word stimulus lists. Note that in order to not confuse participants, the complete pair of picture and name was either new or old; there were no trials where an old picture would appear with a new name or vice versa.

7.1.2 Results

A 2 (Exposure status: old, new; within) X 2 (Consonantal direction: in, out; within) X 3 (Product type: cheese, chocolates, gummy bears; within) repeated measures ANOVA was run on the likelihood of perceiving a stimulus pair as being old. The analysis revealed a significant main effect of exposure status, $F(1, 112) = 27.57$, $p < .001$, $\eta_p^2 = .20$, with previously presented items being categorized as old more often ($M_{old} = .59$, $SE = .01$) than new items ($M_{new} = .53$, $SE = .02$). Crucially, there also was a significant main effect of consonantal direction, $F(1, 112) = 21.24$, $p < .001$, $\eta_p^2 = .16$, with inward pseudo-words being categorized as old more often ($M_{in} = .59$, $SE = .02$) than outward pseudo-words ($M_{out} = .53$, $SE = .02$). A third main effect of product type emerged, $F(2, 111) = 12.07$, $p < .001$, $\eta_p^2 = .10$, with higher likelihood of old judgments for gummy bears ($M_{gummy} = .60$, $SE = .02$) over cheeses ($M_{cheese} = .56$, $SE = .02$) over chocolates ($M_{choc} = .52$, $SE = .02$; all pairwise comparisons significant with all ts > 2.38, all ps ≤ 0.019). There were no interactions between any of the factors, all Fs ≤ 2.23, all ps ≥ .138. A Bayesian Repeated Measures ANOVA confirmed this result, with the model including only the three main effects of exposure status, consonantal direction, and product type having the highest Bayes Factor, $BF_{10} = 1.61 \times 10^{15}$. Figure 6 displays the main effects of exposure status and consonantal direction across the three different product types.

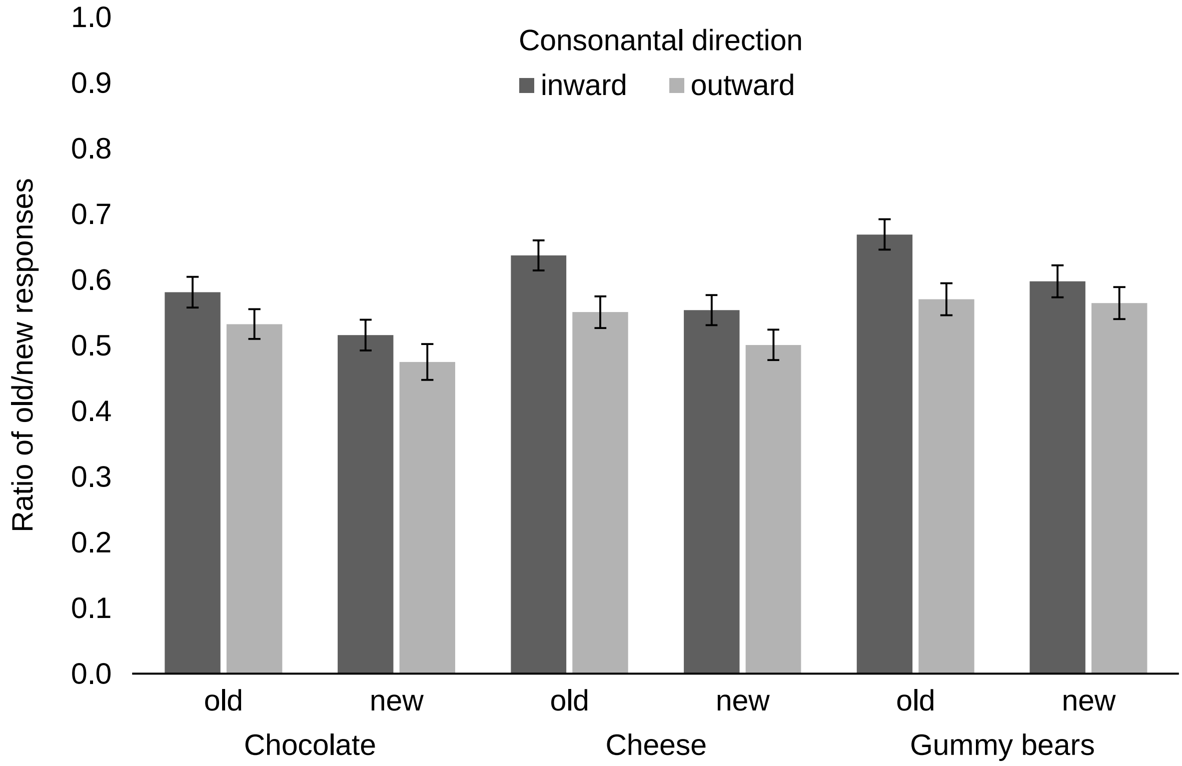


Figure 6: Mean ratios of old/new responses for inward and outward pseudo-words by exposure status and product type (error bars are *SEM*s); bars labeled “old” represent hits, bars labeled “new” represent false alarm rates.

The same pattern of results emerged in a 2 (Exposure status: old, new; within) X 2 (Consonantal direction: in, out; between) X 3 (Product type: cheese, chocolates, gummy bears; within) mixed ANOVA on the item level: I found significant main effects of consonantal direction, $F(1, 140) = 23.26$, $p < .001$, $\eta_p^2 = .14$, as well as exposure status, $F(1, 140) = 20.17$, $p < .001$, $\eta_p^2 = .13$, and product type, $F(2, 139) = 11.16$, $p < .001$, $\eta_p^2 = .07$, but no interactions, all Fs < 1.93, all ps ≥ .166. Again, the model with the three main effects and without interactions had the highest Bayes Factor in a Bayesian mixed ANOVA, $BF_{10} = 4.67 \times 10^8$.

A GLMM analysis confirmed the results of the two ANOVAs: The model included exposure status (contrast coded: old = 0.5, new = -0.5), consonantal direction (contrast coded: in = 0.5, out = -0.5), and product type (2 contrasts; one testing chocolates against the two other types [-1, 0.5, 0.5], the second testing cheese against gummy bears [0, -0.5, 0.5]), as well as all possible interactions as fixed effects, with items and subjects as crossed random factors. Intercepts were allowed to vary randomly across both items and subjects. Slopes for the effect of consonantal direction were allowed to vary randomly across subjects. Random slopes for the effects of exposure status and product type were excluded from the final model, because their inclusion led to convergence failures. The analysis showed significant main effects for exposure status, $\chi^2(1) = 29.93$, $p < .001$, $OR = 1.30$, 95% CI_{OR} [1.18, 1.42], and consonantal direction, $\chi^2(1) = 15.00$, $p < .001$, $OR = 1.34$, 95% CI_{OR} [1.16, 1.54]. There was also again a main effect of product type $\chi^2(2) = 32.97$, $p < .001$, with chocolate pictures being rated as old less frequently than cheese and gummy bear pictures ($OR = 1.18$, 95% CI_{OR} [1.11, 1.26], $z = 4.98$, $p < .001$) and cheese pictures being rated as old less frequently than gummy bear pictures ($OR = 1.19$, 95% CI_{OR} [1.06, 1.33], $z = 2.89$, $p = .004$). No significant interaction effect was found, all χ^2s < 2.88, all *p*s > .089. Variances of random effects are again displayed in Appendix B.

Finally, when averaging old/new responses over the three product types, a comparison of discriminability and response bias between inward and outward pseudo-words in an SDT analysis again revealed a significant difference in *C*, $M_{difference\_C\text{-}in\_C\text{-}out} = -0.19$, $t(112) = -4.54$, 95% $CI_{difference}$ [-0.27, -0.11], $p < .001$, $d_z = -0.59$, $BF_{10} = 1.07 \times 10^3$, but no significant difference in *d-prime*, $t(112) = 0.17$, $p = .863$, $BF_{10} = 0.11$.

7.1.3 Discussion

The significant main effect of inward versus outward consonantal direction on old/new ratings I found in this experiment suggests that the in-out-effect of product names on familiarity persists even when other salient cues such as product pictures are present. This is especially interesting given the subtlety of the consonantal direction manipulation of which participants are generally completely unaware (Topolinski et al., 2014). The result that effects of consonantal direction replicated in the presence of competing visual information is in line with previous findings on the in-out preference effect (Topolinski & Boecker, 2016b, Experiment 3).

However, Topolinski and Boecker (2016b, Experiment 2) found that when presented food pictures varied in terms of their attractiveness, this information dominated palatability ratings and no additional effect of consonantal direction was apparent anymore. It is therefore possible that if pictures had been chosen that were less similar to one another in each product category in the current experiment, the effect of consonantal direction on old/new judgments might have disappeared. This possibility was not tested, however, because a greater variability within the chosen picture stimuli would have simply rendered pictures easier to recall, and this improved recollection would have reduced the reliance on feelings of familiarity in the recognition test. The elimination of an effect of consonantal direction by greater picture variability in a recognition test would therefore be a rather trivial finding that would not provide further insight into the effects of consonantal direction on familiarity. With regard to the potential applications of the effect, it also needs to be noted that in a supermarket, for example, products of one category are usually presented alongside each other, with little difference in the appearance of the products themselves or even their product packaging except for brand and product names. These findings of the current experiment therefore suggest that choosing an inward directed name for a brand or product can indeed increase its respective perceived familiarity. An open question remains, however, whether this effect on familiarity is only evident in an indirect measure such as a recognition memory test, or whether participants would also explicitly report a feeling of familiarity when confronted with inward brand or product names.

7.2 Experiments 3a and 3b

To directly assess perceived familiarity of inward versus outward brand names, I asked for explicit familiarity ratings of the stimuli from the first two experiments in Experiment 3a. In Experiment 3b, I used the same setup but a different stimulus pool and cover story to ensure that the effects I find are not limited to a specific type of stimulus.

7.2.1 Method

Participants. N = 50 participants took part in Experiment 3a (31 female, 19 male, mean age 23, SD = 4) without any exclusions. Another 57 participants took part in Experiment 3b, three of which had to be excluded because of incomplete data, resulting in a final sample of N = 54 participants (25 female, 29 male, mean age 25, SD = 5).

Materials and Procedure. In Experiment 3a, the stimuli were identical to the pseudo-word stimuli from Experiment 1, except that one of the 142 stimuli, namely UBER, was excluded because it represented an existing brand name. As a cover story, participants were told that they would now see names of different Asian and African stock companies and should simply indicate whether that stock company seemed familiar to them or not. The exact instructions (translated from German) were as follows:

> *"At the stock market, stocks of numerous different companies are traded every day. Apart from the classic European and American publicly traded companies, the market is increasingly opening up to Asian and African companies. In the following experiment we would like to present you with the names of a number of such companies and to find out whether you have heard of them before. Please indicate for every company how familiar it seems to you. For this, please enter a number from 0 NOT AT ALL FAMILIAR to 10 VERY FAMILIAR."*

For each participant, 72 of the stimuli were randomly drawn from the stimulus pool and presented one at the time. Each pseudo-word was visible on screen for 1000 ms, after which a window popped up in which participants were asked to indicate how familiar this stock company name seemed to them from 0 (= not at all familiar) to 10 (= very familiar).

The setup of Experiment 3b was identical to Experiment 3a, with the exception that a different set of stimuli as well as a slightly different cover story were used. The new set of stimuli was originally created and tested by Topolinski and Boecker (2016a). It also consists of four letter pseudo-words with two consonants and two vowels each, creating consonantal inward and outward pseudo-words, but in this case the order is reversed, starting with a consonant and ending with a vowel (CVCV; e.g. PIKA, inward, or GUBI, outward). The consonants were again the six clear front and back consonants in German phonation (B, M, P; G, K, R), combined with all possible vowel combinations (excluding occurrences of the same vowel twice in one pseudo-word). Accidental meaningful combinations were excluded from the stimulus list. See Appendix A for a full list of the stimuli. Because the stimuli include random vowels, the total number of stimuli was about twice as large as in the set of stimuli used in Experiments 1 through 3a, namely 295 pseudo-words (146 inward, 149 outward). Therefore, the number of trials was increased, with every participant rating a random subset of 100 pseudo-words (50 inward, 50 outward). The stimuli in this experiment were presented as small international clothing brands, and participants' task was again to rate every brand name for familiarity:

> *"Through online markets and mail order trading it has become possible even for small enterprises to sell their products internationally. This applies for instance to clothing manufacturers. We are interested in the familiarity of such international clothing brands. Therefore, in the following experiment we would like to present you with the names of a number of such brands and to find out whether you have heard of them before. Please indicate for every brand how familiar it seems to you. For this, please enter a number from 0 NOT AT ALL FAMILIAR to 10 VERY FAMILIAR."*

7.2.2 Results

Experiment 3a. Across all trials, nine mistyped trials had to be excluded (< 1 %). A total of 16 participants answered 0 (= not at all familiar) for all trials. I did not exclude these participants because it can be a valid and truthful response to report that none of the stimuli seemed familiar, given that the stimuli were actually novel pseudo-words presented as brand names. A paired-samples *t*-test comparing the mean familiarity rating of consonantal inward and outward pseudo-words revealed higher familiarity ratings for inward (M_{in} = 0.98, *SE* = 0.26) than outward pseudo-words (M_{out} = 0.84, *SE* = 0.24), $M_{\text{difference\_in-out}}$ = 0.14, $t(49) = 3.26$, 95% $\text{CI}_{\text{difference}}$ [0.05, 0.23], $p = .002$, $d_z = 0.46$, $BF_{10} = 15.11$. As can be seen, the means were very low and had large standard errors based on the frequent 0 or 1 ratings of many participants, combined with ratings of fewer participants who used the full range of the scale. On the item level, this difference between inward and outward pseudo-words was not significant, $t(139) = 1.90$, 95% $\text{CI}_{\text{difference}}$ [-0.01, 0.27], $p = .060$, $d = 0.32$, $BF_{10} = 0.93$. Taking both subject and item variance into account, a linear mixed model on the trial level confirmed the results of the first *t*-test: The model included consonantal direction (coded as in = 0.5 vs. out = -0.5) as a fixed effect, with items (pseudo-word stimuli) and subjects as crossed random factors. Intercepts were allowed to vary randomly across both items and subjects, and slopes for consonantal direction were allowed to vary randomly across subjects. The analysis revealed a significant main effect of consonantal direction, $F(1, 72.94) = 6.14$, $p = .016$, estimate of fixed effect B = 0.14, SE = 0.06, mean difference 95 % CIs [0.03, 0.25]. For variances of random effects, see Appendix B.

Experiment 3b. Overall, seven mistyped trials had to be excluded (< 1 %). A total of 16 participants answered 0 on all trials. As in Experiment 3a, these participants were not excluded. Again, a paired-samples t-test showed higher familiarity ratings for inward (M_{in} = 0.81, SE = 0.24) compared to outward pseudo-words (M_{out} = 0.71, SE = 0.23), $M_{difference\_in\text{-}out}$ = 0.09, $t(53)$ = 2.59, 95% $CI_{difference}$ [0.02, 0.17], p = .012, d_z = 0.35, BF_{10} = 3.03. Similarly to Experiment 3a, means were low and had large standard errors, highlighting the generally low familiarity ratings by the majority of participants, while the other participants rendered ratings using the full range of the scale. On the item level, this difference was not significant, $t(293)$ = 1.64, 95% $CI_{difference}$ [-0.02, 0.19], p = .101, d = 0.19, BF_{10} = 0.46. A linear mixed model with the same specifications as in Experiment 3a found a main effect of consonantal direction, $F(1, 80.32)$ = 5.36, p = .023, estimate of fixed effect B = 0.09, SE = 0.04, mean difference 95 % CIs [0.01, 0.17]. Random effects are displayed in Appendix B. Figure 7 illustrates the findings of Experiments 3a and 3b.

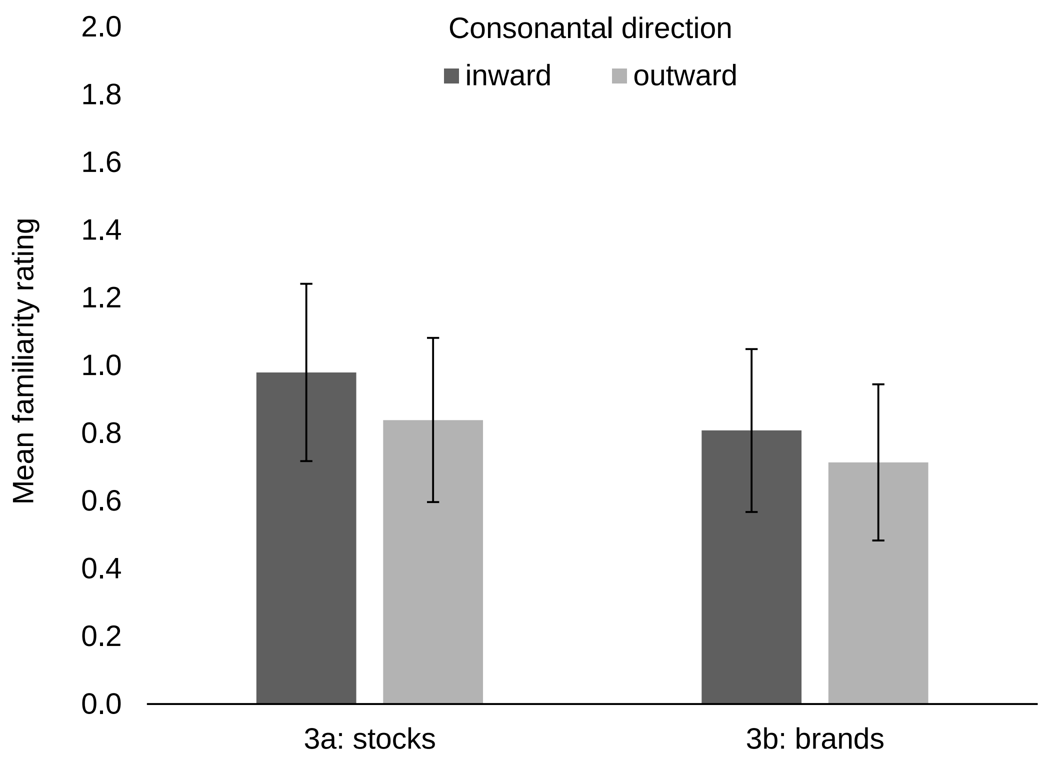


Figure 7: Mean familiarity ratings for inward and outward pseudo-words as names of stock companies (Exp. 3a) or clothing brands (Exp. 3b). Error bars represent *SEM*s.

7.2.3 Discussion

Both Experiments 3a and 3b found a significant consonantal in-out-effect on explicit ratings of familiarity. This effect appeared although a number of participants answered 0 on every trial; either because they were not motivated to read the names or, just as likely, because they were acknowledging that all pseudo-words seemed new, hence unfamiliar, to them. The large number of 0 ratings is reflected in the low means and large standard errors and also can explain why the effect was not significant on the item level: Each participant saw approximately half of the item pool in Experiment 3a, and a third of the item pool in Experiment 3b. Therefore, each item in Experiment 3b was rated only by 18 participants on average. While it does not affect the effect of consonantal direction on subject level if a participant answered 0 on all trials, it does make a difference on the item level. If some items were rated disproportionally often by such participants, the mean would be lower for that specific item. Nevertheless, the linear mixed model analysis confirmed the effect of consonantal direction on familiarity. The results demonstrate that the effect extends to more direct measurements of familiarity than responses in a recognition task.

Chapter 8 – Familiarity versus Mere Response Tendency

Experiments 2, 3a, and 3b provide evidence that the in-out familiarity effect persists when other salient cues are available and when people are asked directly about their experience of familiarity. These results underline the robustness of the effect. In fact, when reviewing the results of Experiment 1, it is striking that statistically the effect of consonantal direction on old-new responses was even stronger than the impact of actual exposure status. This finding together with the in-out preference effect previously described in the literature (Topolinski et al., 2014) raises the question whether an alternative explanation for the observed pattern might be that people show a general endorsement tendency of inward over outward pseudo-words (see also acquiescence; Cronbach, 1946). Although participants had to press a key for both old and new stimuli, the instructions still put an emphasis on identifying old stimuli which might have reframed “old” as the affirmative and “new” as the negative response. A general endorsement or affirmation tendency towards inward pseudo-words could therefore also have led to more frequent “old” responses, independent of perceived familiarity, which was ruled out in Experiment 4.

8.1 Experiment 4

To rule out the alternative explanation of a general endorsement tendency regarding inward pseudo-words, I implemented a Go/No-go paradigm (Donders, 1868/1969; Gomez, Ratcliff, & Perea, 2007; Perea, Rosa, & Gómez, 2002) as another recognition task (e.g., Boldini, Russo, & Avons, 2004) in the fourth experiment, instructing participants to either identify only old or only new pseudo-words (e.g., Windmann & Chmielewski, 2008). The idea behind this approach is that by asking participants *not* to react to old, familiar stimuli in the condition where they will identify the new words via key press, the two potential explanations predict contrary findings: Higher perceived familiarity of inward pseudo-words should lead to *fewer* reactions towards inward stimuli in this condition because a response means *new*, whereas a general endorsement tendency would lead to *more frequent* reactions towards inward stimuli because this is the affirmative response to the question posed.

8.1.1 Method

Participants. N = 120 participants took part in the experiment. Data for three participants was excluded because it was incomplete, resulting in a sample of N = 117 participants (102 female, 15 male, mean age 22, SD = 3).

Materials and Procedure. The stimuli as well as the study phase were identical to Experiment 1. For the test phase however, instructions differed: Half of the participants (N = 59) were instructed to only identify the stimuli that had been previously presented. If they recognized a stimulus as old, they should press the space bar. If they thought the stimulus was new, they were instructed not to react. After a reaction time window of 2000 ms, the program automatically proceeded to the next trial if no reaction had occurred. The other half of participants (N = 58) received the opposite instructions: They were asked to react to new stimuli only and to do nothing if they thought the stimulus had been previously presented. Implementing a Go/No-go paradigm with these competing instructions allowed me to reframe an “old” response as affirmative in one condition and as negative in the other, thereby making it possible to disentangle reactions based on an endorsement tendency from reactions based on familiarity. Specifically, in the critical “identify new” condition, a general endorsement tendency towards inwards pseudo-words should lead to increased affirmative reactions towards inwards pseudo-words (in this case, “new” responses). If inward pseudo-words elicit stronger feelings of familiarity than outward pseudo-words, however, the pattern should be reversed: Participants should react *less* frequently to inward compared to outward pseudo-words, thereby categorizing them as previously seen.

8.1.2 Results

As can be seen in Figure 8a, the ratio of reactions versus non-reactions was indeed reversed in the "identify new" condition, while the pattern in the "identify old" condition resembled the findings from Experiment 1. By reversing the scores in the "identify new" condition by the formula 1-x, I transformed them into old/new ratios, which can be seen in Figure 8b: A reaction ratio of 0.3 in the "identify new" condition, for example, would indicate that participants reacted to 30% of the trials, meaning they did not react to 70% of the trials, which in this condition qualified as an "old" response. The score on the old/new ratio would therefore be 0.7.

Using these old/new ratios, I ran a 2 (Exposure status: old, new; within) X 2 (Consonantal direction: in, out; within) X 2 (Instruction: identify old, identify new; between) mixed-model ANOVA. The analysis again revealed both a main effect of exposure status, $F(1, 115) = 37.20$, $p < .001$, $\eta_p^2 = .24$, with previously presented items being categorized as old more often ($M_{old} = .66$, $SE = .01$) than new items ($M_{\text{new}} = .59$, $SE = .01$), and a main effect of consonantal direction, $F(1, 115) = 43.09$, $p < .001$, $\eta_p^2 = .27$, with inward pseudo-words being categorized as old more often ($M_{in} = .66$, $SE = .01$) than outward pseudo-words ($M_{\text{out}} = .58$, $SE = .01$). In addition, there was a significant main effect of instruction, $F(1, 115) = 16.62$, $p < .001$, $\eta_p^2 = .13$, with pseudo-words being categorized as old more often in the "identify new" ($M_{\text{ident\_new}} = .66$, $SE = .02$) than in the "identify old" condition ($M_{\text{ident\_old}} = .57$, $SE = .02$). No interaction between any of the variables was significant, all Fs < 1.13, all ps ≥ .291. A Bayesian Repeated Measures ANOVA confirmed the model with three main effects but no interactions as the most likely model, $BF_{10} = 4.15 \times 10^{17}$.

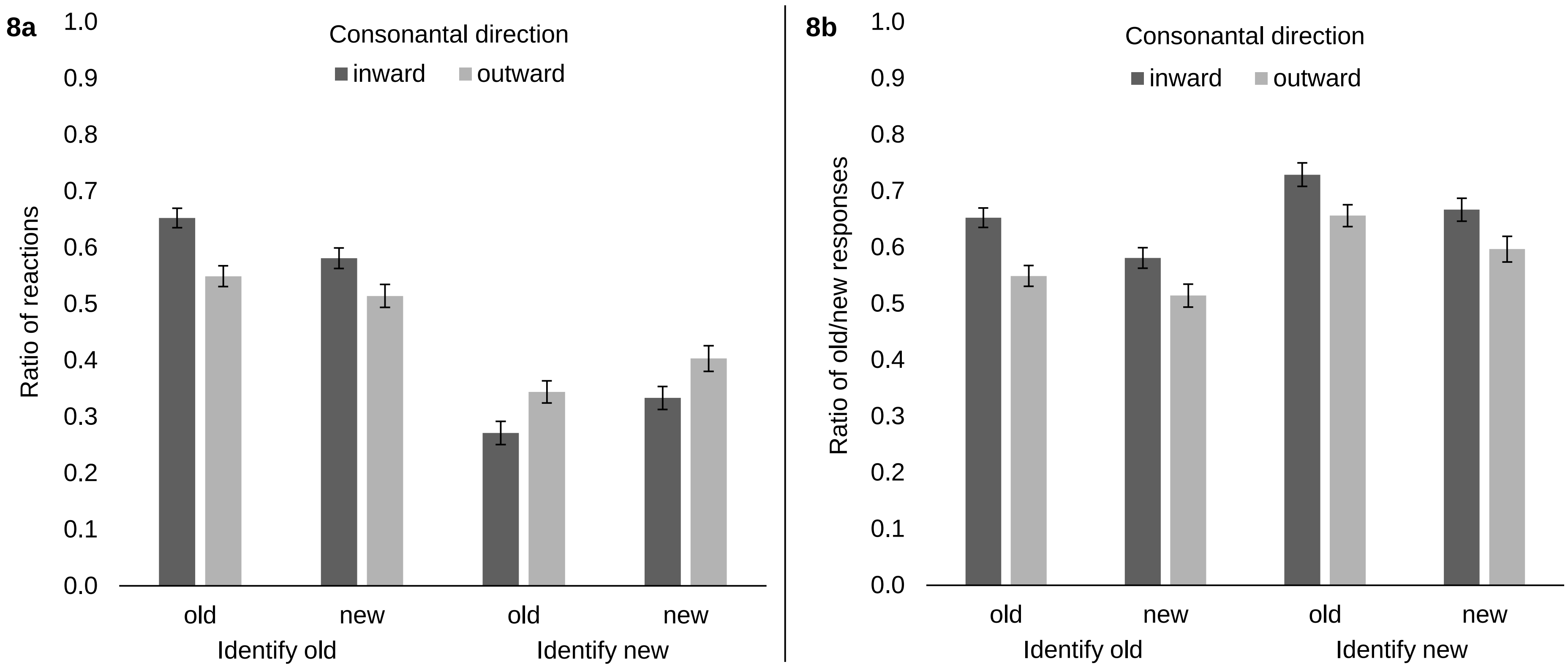


Figure 8: Figure 8a illustrates the ratio of reactions towards old and new inward and outward pseudo-words in the two Go/No-go instruction conditions. Figure 8b displays the same data, with inverted scores in the "identify new" condition to turn them into old/new ratios. Error bars represent *SEM*s.

To take item variance into account, I again ran a 2 (Exposure status: old, new; within) X 2 (Instruction: identify old, identify new; within) X 2 (Consonantal direction: in, out; between) mixed ANOVA on the item level, which confirmed the significant effects of consonantal direction, $F(1, 140) = 21.75$, $p < .001$, $\eta_p^2 = .13$, as well as exposure status, $F(1, 140) = 20.20$, $p < .001$, $\eta_p^2 = .13$, and instruction $F(1, 140) = 68.68$, $p < .001$, $\eta_p^2 = .33$, but no interaction of any of the factors, all Fs < 0.70, all ps ≥ .407. The model including only the three main effects without any interaction again also had the highest Bayes Factor, $BF_{10} = 6.05 \times 10^{20}$. A generalized linear mixed model analysis was run with the same specifications as in Experiment 1, only with the factor instruction (contrast coded: identify new = 0.5, identify old = -0.5) and its interactions with the other variables as additional fixed factors. In addition to random intercepts for participants and items, slopes for the effect of previous exposure were allowed to vary randomly across items, and slopes for the effect of consonantal direction was allowed to vary randomly across participants. This final model was reached by sequentially excluding the remaining possible random slopes from the maximal model until the model converged, as described in Experiment 1 (Barr et al., 2013). The findings supported the previous results, replicating the main effects of exposure status, $\chi^2(1) = 20.13$, $p < .001$, $OR = 1.29$, 95% CI_{OR} [1.16, 1.43], and consonantal direction, $\chi^2(1) = 19.21$, $p < .001$, $OR = 1.45$, 95% CI_{OR} [1.24, 1.71], as well as instruction, $\chi^2(1) = 16.21$, $p < .001$, $OR = 1.51$, 95% CI_{OR} [1.25, 1.84]. There were no significant interaction effects between any of the variables, all χ^2s < 0.88, all ps ≥ .350. Variances of random effects are displayed in Appendix B.

The comparison of discriminability and response bias between inward and outward pseudo-words using an SDT approach again revealed a significant difference in C, $M_{difference\_C-in\_C-out} = -0.24$, $t(116) = -6.33$, 95% $CI_{difference}$ [-0.31, -0.16], $p < .001$, $d_z = -0.59$, $BF_{10} = 2.18 \times 10^6$, but no significant difference in *d-prime*, $t(116) = 1.37$, $p = .174$, $BF_{10} = 0.25$.

8.1.3 Discussion

The results of Experiment 4 replicated the impact of consonantal direction on feelings of familiarity and ruled out a general acquiescence tendency as an alternative explanation: In the “identify new” condition, the reaction pattern was indeed reversed, showing fewer reactions towards inward compared to outward pseudo-words (see Figure 8a). When these scores were transformed into old/new ratios and entered into a mixed-model ANOVA, the factor instruction did not interact with consonantal direction or exposure status and therefore does not seem to have an influence on either of these two effects. There was merely a conceptually irrelevant main effect of instruction, with participants in the "identify new" condition showing an overall higher tendency *not* to react than in the "identify old" condition. What is still unclear though, is to what extent participants' responses were based on actual recollection versus familiarity-based judgments. Would the effect of consonantal direction disappear if participants were told to only rely on recollection? This is the question I addressed in the following chapter in Experiment 5.

Chapter 9 – Familiarity versus Recollection

In the experiments presented thus far, I have assumed that consonantal inward compared to outward pseudo-words elicit higher feelings of familiarity, based on findings of both higher hit and false alarm rates, as well as a more liberal response criterion in SDT analyses. According to dual process models of recognition memory, though, these familiarity-based judgments as described by signal detection models are only one of two processes influencing recognition performance: The dual process models assume a second, separate mechanism, namely recollection (e.g., Atkinson & Juola, 1974; Jacoby, Toth, & Yonelinas, 1993; Mandler, 1980; Yonelinas, 1994, 1997, 1999). In these models, familiarity has been characterized as an automatic, continuous process, whereas recollection has been considered a controlled retrieval process that can only succeed or fail depending on whether the strength of recollection exceeds a critical threshold (Atkinson & Juola, 1974; Jacoby et al., 1993; Mandler, 1980). This assumption has been tested and supported by a large number of studies using process dissociation procedures (e.g., Jacoby, 1991; Jacoby et al., 1993), remember/know judgments (Yonelinas & Jacoby, 1995; see also Gardiner, 1988; Tulving, 1885) as well as receiver-operating characteristics (ROC; e.g. Yonelinas, 1994, 1999, 2001). For example, Jacoby et al. (1993; Experiment 1) presented participants with word stems and asked them to complete them so that they would either result in a word that was previously presented in a study phase (inclusion instruction) or in a word that was specifically *not* presented before (exclusion instruction). While both accurate recollection and familiarity would contribute to a correct solution under inclusion instructions, completing the word stem with a previously presented word under exclusion instructions would reflect familiarity and a *failure* of recollection, because accurate recollection should have prevented the use of a presented word. Combining responses from the inclusion and exclusion phases therefore allowed Jacoby et al. (1993) to dissociate familiarity from recollection processes. The ROC-procedure, on the other hand, combines recognition judgments with confidence ratings and then plots hits and false alarms against each other at the various levels of confidence (e.g. Yonelinas, 1999): Based on the assumption that recollection is usually accompanied by high confidence, whereas confidence for familiarity-based judgments is more normally distributed, the curvilinearity of the resulting distribution then reflects reliance on familiarity, whereas the skewness or asymmetry of the curve reflects recollection. Thirdly, the remember/know paradigm involves a classical recognition task as I have employed it in the previous experiments, with the additional instruction to indicate after each “old” judgment whether one can *remember* the stimulus (i.e., the situation when it was presented, details of the context) or whether one *knows* the stimulus (i.e., without being able to specifically remember the previous exposure). It has been argued that *remember* judgments reflect recollection, whereas *know* judgments reflect familiarity (e.g., Gardiner, 1988; Yonelinas & Jacoby, 1995). Gardiner (1988; Experiment 1), for example, showed that the number of accurate *remember* judgments in a recognition test increased when participants were required to semantically process words in a study phase instead of only phonemically processing them, while there was no effect of processing level on *know* judgments.

Overall, the results obtained by the different procedures (inclusion/exclusion process dissociation, ROC, remember/know) are generally concordant (e.g., Yonelinas, 2002), with the exception of remember/know judgments, which under some circumstances seem to reflect different levels of confidence, or memory strength, rather than separate memory processes (Donaldson, 1996; Dougal & Rotello, 2007; Dunn, 2004; Hirshman & Master, 1997; Inoue & Bellezza, 1998; Rotello, Macmillan, Reeder, & Wong, 2005; Xu & Bellezza, 2001). Based on these findings, theories have claimed that recollection and familiarity might be based on a single continuous process that determines signal strength in a recognition test (Heathcote, Raymond, & Dunn, 2006; Mickes, Wais, & Wixted, 2009; Wixted, 2007), thereby being more in line with signal detection theory. But because single-process models fail to explain why different factors (such as processing level, Gardiner, 1988) selectively affect recollection or familiarity (Yonelinas, Aly, Wang, & Koen, 2010), the dual process view has been widely defended (e.g., Diana, Reder, Arndt, & Park, 2006; Mandler, 2008; Yonelinas & Jacoby, 2012). Recent theories have attempted to reconcile the two types of process models by assuming two separate processes of familiarity and recollection, but regarding recollection as a continuous process like familiarity, rather than a threshold process (Slotnik, 2010; Wixted & Mickes, 2010). Whether recollection is indeed continuous or a threshold process is not relevant for the present work, however. My hypothesis was that consonantal direction should only influence familiarity, but not recollection. Therefore, it is necessary to assess recollection separately from familiarity.

9.1 Experiment 5

One possibility to address the question whether consonantal direction not only influences familiarity, but also recollection, is to try to eliminate any familiarity-based component in the eventual memory judgment to see if the effect will still persist under those circumstances. This idea follows the remember/know procedure (e.g., Gardiner, 1988, Lindsay & Kelley, 1996; Tulving, 1985; Yonelinas, & Jacoby, 1995), but with the difference that *know* judgments were not assessed (as suggested by Migo, Mayes, & Montaldi, 2012; see Topolinski, 2012; Experiment 1-4). In the current experiment, I opted to exclude familiarity-based judgments instead of assessing them separately because the inward and outward pseudo-words are highly similar and consequently difficult to recollect; therefore, I expect that familiarity-based judgments are much more frequent and might easily conceal recollection based effects. To eliminate familiarity-based judgments, participants were specifically instructed to answer solely based on their recollection of the pseudo-words from the study phase (see Lindsay & Kelley, 1996, Koen & Yonelinas, 2010; Topolinski, 2012). If the effect of consonantal direction were to disappear under these conditions, this would support the claim that the effect is based on familiarity alone.

9.1.1 Method

Participants. A total of N **=** 80 people participated in the study (60 female, 20 male, mean age 24, SD = 5).

Materials and Procedure. Stimuli and experimental procedure were identical to Experiment 1, with the exception of an additional instruction and different labeling of the response options. After the initial recognition task instruction to indicate whether a stimulus had been presented before by responding with „yes" (equivalent to "old" in the previous experiments) or „no" (equivalent to "new"), participants read the following text (original in German):

„Please only answer YES if you can actually remember the moment when you saw the word. This should include a specific memory. For example, you might remember what you were thinking in that moment or what was just happening in the laboratory, such as a noise from outside or a movement from another participant. Please try not to falsely react with YES to a new word. It is normal to only concretely remember a few words."

The intention of this instruction was to prompt participants to rely mostly on their actual recollection while reducing judgments based on mere feelings of familiarity.

9.1.2 Results

Given that the yes/no responses were equivalent to old/new responses, I again calculated old/new ratios for the different categories of pseudo-words. A 2 (Exposure status: old, new; within) X 2 (Consonantal direction: in, out; within) repeated measures ANOVA replicated the patterns from previous experiments: There was a main effect of exposure status, $M_{\text{old}} = .36$, $SE = .03$, $M_{\text{new}} = .29$, $SE = .03$, $F(1, 79) = 24.74$, $p < .001$, $\eta_p^2 = .24$, as well as a main effect of consonantal direction, $M_{\text{in}} = .37$, $SE = .03$, $M_{\text{out}} = .28$, $SE = .03$, $F(1, 79) = 42.72$, $p < .001$, $\eta_p^2 = .35$. The interaction between the two factors was not significant, $F(1, 79) = 0.33$, $p = .570$. The model with only two main effects had the highest Bayes Factor, $BF_{10} = 1.31 \times 10^{17}$. Compared to Experiment 1, "old" responses were substantially lower (by about 50%); however, this decline was present for all factor combinations, and the main effect of consonantal direction remained highly significant. The means are displayed in Figure 9. Since this finding already clearly indicates that the manipulation did not have the intended effect, no further item based or mixed model analyses were run on this data.

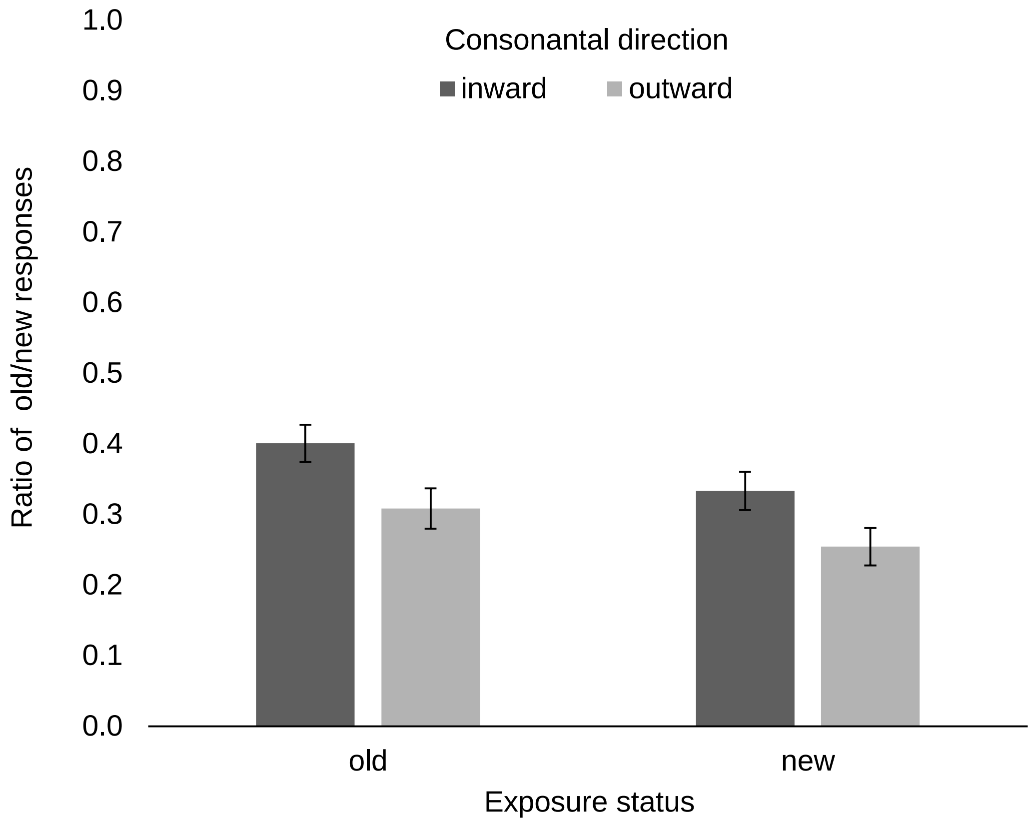


Figure 9: Mean ratios of old/new responses for inward and outward pseudo-words by exposure status (error bars are *SEM*s); bars labeled “old” represent hits, bars labeled “new” represent false alarm rates.

9.1.3. Discussion

Although the additional instructions influenced participants to answer more conservatively overall, they do not seem to have eliminated familiarity based ratings, given the relatively high false alarm rates. Note that the effect size was actually larger for the effect of consonantal direction than for the effect of exposure status. Consonantal direction therefore influenced participants’ judgments more than the actual previous presentation, an effect opposite to what would be expected if participants indeed based their judgments on recollection. It is possible that recollection was generally so low that participants kept relying on familiarity, despite the instruction not to. This is in line with previous criticism stating that *remember* instructions do not provide a process-pure assessment of recollection (e.g., Dougal & Rotello, 2007; Dunn, 2004; Rotello et al., 2005). A different procedure is therefore necessary to disentangle the differential influences of familiarity and recollection on responses toward inward and outward pseudo-words.

9.2 Experiment 6

The experiments thus far did not systematically disentangle the respective contributions of recollection and familiarity to the memory distortion by articulation direction that I have found. Therefore, an inclusion/exclusion process dissociation procedure (PDP; Jacoby, 1991, 1998; Jacoby & Kelley, 1992; Yonelinas & Jacoby, 2012) was used to be able to calculate separate recollection and familiarity indices. The independence of familiarity and recollection as measured by the PDP has been challenged based on findings of correlations between the two indices (Curran, & Hintzman, 1995), but this criticism has been rebutted by Jacoby, Begg, and Toth (1997), who showed that such correlations do not imply functional interdependence of the two processes. As outlined in the introduction of this chapter, the PDP offers a more objective dissociation of familiarity and recollection in contrast to subjective remember/know judgments, because familiarity and recollection lead to contrary predictions in the exclusion phase of the procedure. With regard to the effect of consonantal direction, I hypothesized that while familiarity scores should be higher for inward compared to outward pseudo-words, there should be no difference in recollection.

9.2.1 Method

Participants. Out of a total of 298 participants, five needed to be excluded because of incomplete data, resulting in a final sample of N = 293 participants (229 female, 59 male, 5 missing values, mean age 23, SD = 5).

Materials and Procedure. The stimuli from the previous experiments were divided into two sets of 66 stimuli each; 33 inward and 33 outward. Both sets were then divided into three lists, resulting in six lists total containing 22 stimuli each; 11 inward and 11 outward. The first three lists were always used in the first part of the experiment, the latter three in the second part. The two parts of the experiment were always one inclusion and one exclusion task; the order of the two tasks was counterbalanced across participants. Both tasks began with a study phase. In contrast to the previous experiments, the study phase included two lists; pseudo-words in one of the lists were presented in green, pseudo-words in the other list in purple. Order of the lists and assigned colors were randomized across participants. The instructions told participants to try to remember the pseudo-words and the color they were presented in because they would be asked to recall them later. After a short delay of 30 seconds, the recognition test followed: The pseudo-words from the two studied lists were presented again, mixed with pseudo-words from a new list, with all pseudo-words being presented in black. In the inclusion task, participants were asked to simply indicate for each pseudo-word by key press whether it had been presented in one of the lists in the study phase ("yes") or whether it was new ("no"). In the exclusion task, participants were asked specifically whether a pseudo-word had been presented in the green (purple) list and to therefore answer "no" to new pseudo-words as well as pseudo-words from the purple (green) list.

The idea behind the PDP (Jacoby, 1991; Yonelinas & Jacoby, 2012) is that while participants can use their feelings of familiarity (*F*) and their recollection (*R*) for their responses in the inclusion task, recollection and familiarity work against each other in the exclusion condition: A pseudo-word in the "wrong" list feels familiar because it has been presented before, but actual recollection should lead to exclusion because it did not belong to the list in question. Therefore, "yes" responses for to-be-excluded pseudo-words can be interpreted as based on familiarity and a failure of recollection, $Resp_{ex} = F\ (1 - R)$. By subtracting $Resp_{ex}$ from the responses to the same category of stimuli in the inclusion task ($Resp_{inc}$), which are based on familiarity *and* recollection, I can consequently calculate a recollection score, $R = Resp_{inc} - Resp_{ex}$. In addition, I can compute familiarity by rearranging the formula, $F = Resp_{ex}$ / (1 - R). Thus, it is possible to assess the differential effects of consonantal direction on these two types of recognition memory by calculating the recollection and familiarity parameters for inward and outward pseudo-words separately.

9.2.2 Results

I ran a 2 (Memory type: recollection, familiarity; within) X 2 (Consonantal direction: in, out; within) repeated measures ANOVA on the recollection and familiarity parameters. The analysis revealed a main effect of memory type, M_R= .15, *SE* = .01, M_F = .60, *SE* = .01, $F(1, 292) = 866.21$, $p < .001$, $\eta_p^2 = .75$, as well as a main effect of consonantal direction, M_{in} = .40, *SE* = .01, M_{out} = .35, *SE* = .01, $F(1, 292) = 22.56$, $p < .001$, $\eta_p^2 = .07$. More importantly, the interaction between the two factors was significant, $F(1, 292) = 9.61$, $p = .002$, $\eta_p^2 = .03$. I probed this interaction with paired samples *t*-tests, which confirmed the expected pattern of results. There was a significant difference between inward and outward pseudo-words for familiarity, $M_{difference\_F-in\_F-out} = 0.08$, $t(292) = 6.73$, 95% $CI_{difference}$ [0.06, 0.10], $p < .001$, d_z = 0.39, $BF_{10} = 7.52 \times 10^7$, but not for recollection, $t(292) = 1.27$, $p = .205$, $BF_{10} = 0.15$. Figure

10 illustrates the mean recollection and familiarity scores for inward and outward pseudo-words.

Repeating this analysis on the item level yielded the same patterns of results: In a 2 (Memory type: recollection, familiarity; within) X 2 (Consonantal direction: in, out; between) mixed ANOVA on the recollection and familiarity parameters (this time calculated for each item, rather than each participant), I again found significant main effects for memory type, M_R= .16, *SE* = .01, M_F = .59, *SE* = .01, $F(1, 130) = 1465.24$, $p < .001$, $\eta_p^2 = .92$, and consonantal direction, M_{in} = .40, *SE* = .01, M_{out} = .35, *SE* = .01, $F(1, 130) = 17.21$, $p < .001$, $\eta_p^2 = .12$, as well as the interaction between the two factors, $F(1, 130) = 4.38$, $p = .038$, $\eta_p^2 =$ .03. Two independent samples *t*-tests again confirmed a significant effect of consonantal direction on familiarity, $M_{difference\_F\text{-}in\_F\text{-}out}$ = 0.07, $t(130) = 4.79$, 95% $CI_{difference}$ [0.04, 0.11], $p < .001$, *d*= 0.83, $BF_{10} = 3.58 \times 10^3$, but not recollection, $t(130) = 1.50$, $p = .137$, $BF_{10} = 0.52$.[3]

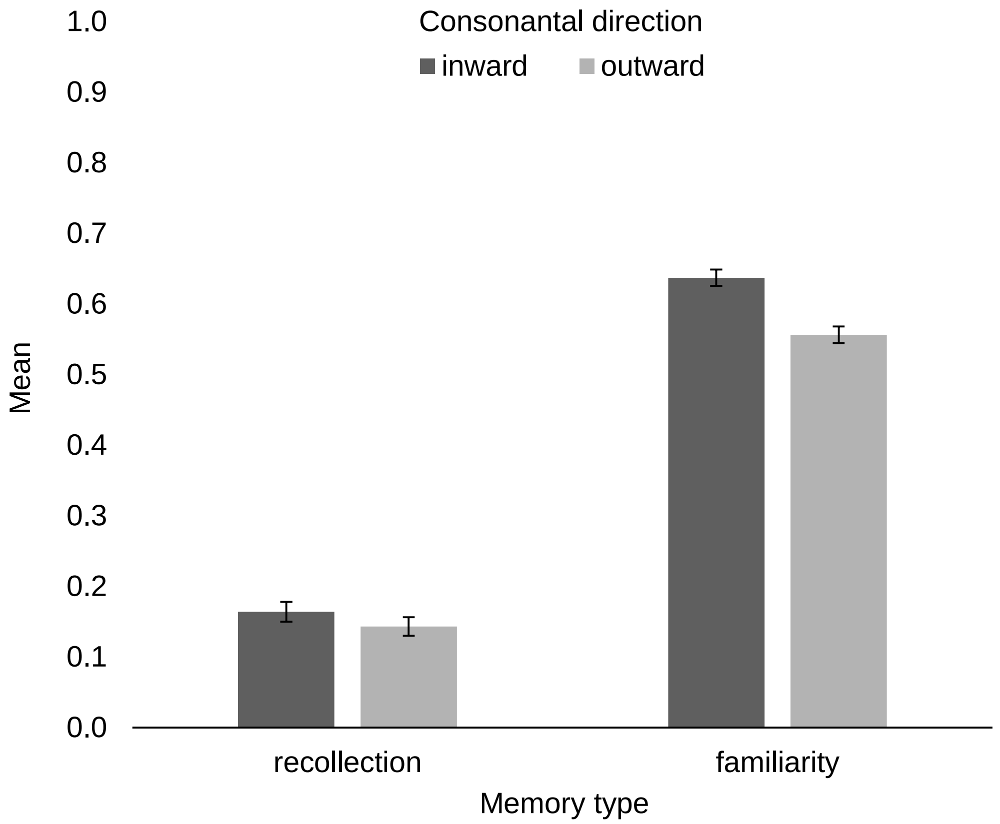


Figure 10: Mean recollection and familiarity scores for inward and outward pseudo-words (error bars represent *SEM*s).

[3] A GLMM analysis could not be run for this study because participants did not see the same items in the inclusion and exclusion phase. Therefore, it is necessary to aggregate over either participants or items to be able to calculate familiarity and recollection indices; the indices cannot be calculated on the trial level.

9.2.3 Discussion

The PDP confirmed my hypothesis that the memory effect of inward-outward articulation in the experiments thus far are driven by the unique influence of articulation dynamics on familiarity, and not recollection (see e.g., LeCompte, 1995; Ozubko & Yonelinas, 2014; Rajaram & Geraci, 2000; Thapar & Westerman, 2009, for a similar dissociation for fluency). Recollection was very low overall, which is not surprising given the high degree of similarity between the stimuli, which were deliberately designed from the same set of vowels and consonants to keep potential confounds at a minimum. The low recollection rate made the PDP especially important, since a potential difference in recollection might have easily been overshadowed in the earlier experiments by the large quantity of familiarity based judgments. The results of Experiment 6 demonstrated that this does not seem to have been the case because I did not find any influence of consonantal direction on recollection. With the significant difference between the familiarity indices for inward and outward pseudo-words, on the other hand, the PDP provided an additional measure that confirmed the previous findings of an effect of consonantal direction on familiarity.

Chapter 10 – Fluency and Liking as Potential Mechanisms behind the In-Out Familiarity Effect

Although Experiments 1 through 6 consistently showed that inward pseudo-words created stronger feelings of familiarity than outward pseudo-words, a question that still remains open is whether this effect of consonantal direction on familiarity is distinct from other previously described effects. For instance, the effect on familiarity might simply be explained by the greater liking of inward over outward pseudo-words (Topolinski et al., 2014; Topolinski & Boecker, 2016a). Because many studies have shown that positivity leads to increased perceptions of familiarity (e.g., Claypool et al., 2008; Garcia-Marques et al., 2004; Garcia-Marques et al., 2010; Monin, 2003), it is possible that the higher familiarity for inward versus outward pseudo-words in the current experiments is due to the positive affect those words elicit. On the other hand, it is also plausible that articulation fluency might be the underlying mechanism driving the familiarity effect: Bakhtiari et al. (2016) showed that there was a difference in subjective and objective articulation fluency between the inward and outward pseudo-words from Topolinski et al. (2014) and argued that this fluency could be responsible for the greater liking of inwards compared to outward pseudo-words. However, their tests of this hypothesis revealed that although fluency partially mediated the in-out preference effect, it did not fully explain the effect, indicating that ease of articulation seems to be only one component of the in-out preference effect. Given that processing fluency is amplified by repeated exposure to stimuli, and thus can be conceptualized as an indicator of familiarity (e.g., Jacoby & Whitehouse, 1989; Whittlesea, 1993), I felt that it was prudent to investigate the impact of fluency on the familiarity effects found in the current experiments.

10.1 Experiment 7

The only existing experiments addressing fluency of inward compared to outward pseudo-words have used the stimuli from Topolinski et al. (2014), which included middle consonants and random vowels (Bakhtiari et al., 2016). Fluency has never been assessed for the more tightly-controlled four-letter stimuli (Topolinski & Boecker, 2016a) I used in the current experiments (Exp. 1, 2, 3a, 4 – 6). A first step before the correlational analysis was therefore to test whether these inward and outward stimuli differed with regard to their subjective fluency. I deliberately decided to measure subjective fluency with rating scales instead of objective fluency, such as reading latency, because all stimuli in this stimulus pool are extremely easy to pronounce: With only four letters they are very short, and with their vowel-consonant-vowel-consonant (VCVC) sequence they follow a very simple pattern. Differences in reading latency were already very small in the experiments run by Bakhtiari et al. (2016; M = 848 ms for inward versus M = 865 ms for outward words), and the stimuli they used were longer and included middle consonants and random vowels. Consequently, differences would be hardly detectable for the type of stimuli I used in the current experiments. Additionally, because familiarity in Experiment 3a and liking in previous studies (Topolinski & Boecker, 2016a) have been measured by subjective ratings, it is reasonable to test fluency in the same way in the current investigation.

10.1.1 Method

Participants. N = 107 participants took part in the experiment. Data of one participant had to be discarded because the person decided to stop the experiment after a few trials, resulting in a sample of N = 106 participants (63 female, 43 male, mean age 23, SD = 5).

Materials and Procedure. In a setup almost identical to Experiment 3a, participants were presented with a random selection of the pseudo-words from Experiment 1 in 72 trials. This time, however, the stimuli were not framed as stock company names, but simply presented as items which need to be pre-tested for a future experiment. For each pseudo-word, they were asked to indicate how hard or easy it would be to pronounce it on a scale from 0 = very hard to 10 = very easy. The range of the scale was therefore identical to the familiarity scale in Experiment 3a, with the only difference that higher values in the former experiment meant higher familiarity, whereas they now indicate higher subjective articulation fluency.

10.1.2 Results

Overall, 17 mistyped trials had to be excluded (< 1 %). A paired-samples *t*-test compared the mean ratings of pronunciation ease between consonantal inward and outward pseudo-words across participants. Inward pseudo-words were rated slightly easier to pronounce (M_{in} = 7.49) than outward pseudo-words (M_{out} = 7.42), although the difference was not statistically significant, $M_{\text{difference\_in-out}}$ = 0.07, $t(105) = 1.62$, 95% $\text{CI}_{\text{difference}}$ [-0.02, 0.16], $p = .108$, $BF_{10} = 0.38$. Consistent results were found on the item level, although this effect also failed to reach significance, $t(139) = 1.36$, 95% $\text{CI}_{\text{difference}}$ [-0.04, 0.20], $p = .175$, $BF_{10} = 0.42$. Given that the difference in subjective fluency was non-significant on both subject and item level, a mixed model analysis would have been superfluous and was therefore not conducted. Figure 11 shows the mean fluency ratings of the inward and outward pseudo-words.

10.1.3 Discussion

Contrary to the findings by Bakhtiari et al. (2016), the inward pseudo-words were not rated as significantly easier to pronounce than the outward pseudo-words. A tendency was apparent in the expected direction, however, suggesting that a small difference might exist but could be difficult to find reliably due to the ease with which all of these simple stimuli could be articulated. In line with my concern that differences in articulation fluency between the inward and outward stimuli would be too small to be detectable by indirect measures of objective fluency such as reading latency, they also seem to be too small to lead to a significant result in subjective ratings. These null effects do not lend support to the notion that articulation fluency explains the in-out familiarity effect, but Study 8 will address this question more directly.

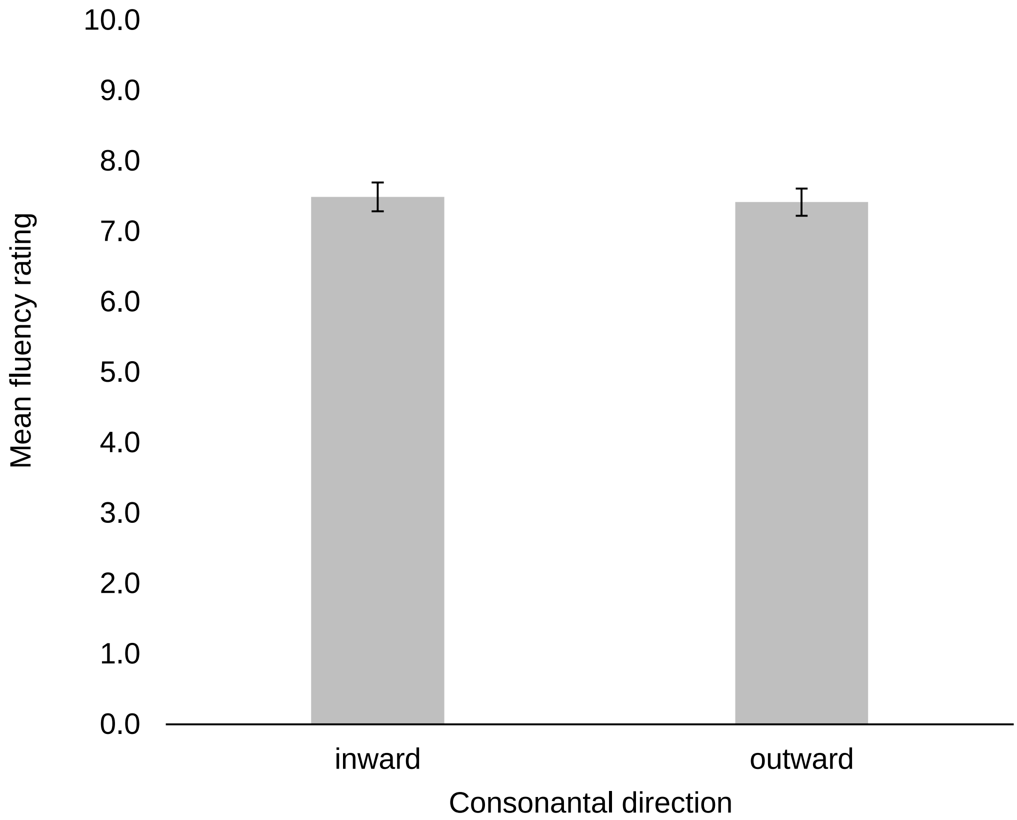


Figure 11: Mean articulation fluency ratings in Experiment 7 for inward and outward pseudo-words (error bars represent *SEM*s).

10.2 Study 8

The purpose of assessing fluency of inward and outward pseudo-words was to gain insight into the origin of the in-out familiarity effect I find consistently throughout these experiments. However, given the lack of support for the fluency hypothesis in Experiment 7, alternatives must be considered. One possibility is that the in-out familiarity effect is driven by higher preference for inward over outward pseudo-words, since such a preference bias has been shown in prior research (Topolinski et al., 2014). Another possibility is that a higher articulation fluency for inward compared to outward pseudo-words is responsible for the increased feeling of familiarity, either directly or indirectly by inducing greater liking of the inward stimuli (Bakhtiari et al., 2016). This was tested in an item based correlational analysis, in which I used the average liking the presently used items received in an earlier study that assessed preference (Topolinski & Boecker, 2016a; Experiment 1b) in addition to the old/new ratios and fluency ratings obtained in the current experiments. Another question is whether the implicit familiarity scores in the form of old/new ratios would correlate with explicit familiarity ratings obtained in Experiment 3a, and how these ratings relate to liking and fluency.

10.2.1 Method

Explicit liking ratings from Experiment 1b in Topolinski and Boecker (2016a) were provided by the authors as raw data for the current analysis. These ratings were obtained on a scale from 0 (“I do not like it at all”) to 10 (“I like it very much”). Therefore, the liking ratings are based on the same scale as the fluency ratings from Experiment 7 and the familiarity ratings from Experiment 3a. The raw data from those experiments were used to calculate a mean liking, fluency, and familiarity score for each item. Familiarity scores from the recognition experiments (Experiments 1, 4 & 5[4]) were computed as the average old/new ratios for each item: Importantly, however, I only used responses to NEW items for this calculation, because in contrast to responses to old items, they are not contaminated by successful recollection or actual familiarity due to previous exposure. Therefore, they serve as a better estimate of the inherent familiarity of the stimuli that I am interested in. For Experiment 6, I used the familiarity parameter *F* that had been calculated for each item.

10.2.2 Results

Table 1 shows bivariate correlations among all the measures of interest. Medium to large correlation coefficients (r = .37 to r = .63) were found across the four recognition experiments. Neither the old/new ratios from Experiments 1, 4, and 5 nor the familiarity index from Experiment 6 correlated with liking ratings from the earlier Topolinski and Boecker (2016a) paper (all rs < |-.10|, all ps ≥ .250). Similarly, fluency only showed a small significant correlation with the old/new ratios from Experiment 4 (r = .18, p = .029), but not with the other recognition experiments. Fluency and liking ratings were correlated at r = .28, p = .001. On the other hand, the measures from all four recognition experiments correlated significantly with the explicit familiarity ratings from Experiment 3a (all rs > .28, all ps ≤ .001). These explicit familiarity ratings did not correlate with liking (r = .08, p = .354) or fluency (r = .14, p = .088).

[4] Data from Experiment 2 was not included in the correlational analysis because the additional visual information in form of product pictures would have added systematic error variance to the analysis.

Table 1:

Pearson Correlations between old/new ratios (Exp. 1, 4 & 5), familiarity index (Exp. 6), liking ratings (Topolinski & Boecker, 2016a; Exp. 1b), fluency ratings (Exp.7), and familiarity ratings (Exp. 3a).

	Old/new ratio Exp. 1	Old/new ratio Exp. 4	Old/new ratio Exp. 5	Fam. index Exp. 6	Liking	Fluency Exp. 7	Familiarity Exp. 3a
Old/new ratio Exp. 1	—	.573***	.427***	.634***	-.098	.099	.321***
Old/new ratio Exp. 4		—	.372***	.530***	.024	.184*	.308***
Old/new ratio Exp. 5			—	.510***	.066	.053	.284**
Fam. index Exp. 6				—	-.004	.156	.351***
Liking					—	.281**	.079
Fluency Exp. 7						—	.144
Familiarity Exp.3a							—

**** Pearson Correlation significant at p < .001*
*** Pearson Correlation significant at p < .01*
** Pearson Correlation significant at p < .05*

Mediation Analysis. A mediation analysis would typically be necessary to test whether the assumed mediator variables are actually responsible for indirect effects of the independent variable on the dependent variable. For such a mediation, it is generally considered a requirement that the potential mediator is correlated both to the independent variable and the outcome variable (Baron & Kenny, 1986). As can be seen in Table 1, however, the first potential mediator, liking, does not even correlate with any of the outcome variables. A similar pattern exists with the second potential mediator, fluency. Fluency did not correlate with the old/new ratios or familiarity indices and ratings, with the exception of the old/new ratios of Experiment 4. It is therefore unlikely that liking or fluency could mediate the effect of consonantal direction on measures of recognition and familiarity in the present experiments. Because it has been argued that missing correlations do not necessarily invalidate a potential mediation (e.g., Hayes, 2013), I nevertheless ran mediation analyses using the PROCESS macro in SPSS (see Hayes, 2013) which employs a bootstrapping procedure. All five mediation analyses (with the old/new ratios from Experiments 1, 4, 5, the familiarity index from Experiment 6, and familiarity ratings from Experiment 3a as outcome variables) using 5000 bootstrap samples each only found direct effects of consonantal direction on the outcome variables, but no indirect effects through fluency or liking (all CIs included 0), with one exception: The mediation analysis on the data of Experiment 1 actually found even a small *negative* indirect effect of consonantal direction on old/new ratios mediated by liking (B = -0.03, SE = 0.01, 95 % CI [-0.05, -0.01]), which was also found again as a tendency regarding the familiarity index in Experiment 6 (B = -0.01, SE = 0.01, 95 % CI [-0.03, -0.004]), but not by the other mediation analyses.

10.2.3 Discussion

Contrary to the hypothesis that the observed familiarity effects in the four experiments might be mediated by a greater liking for inward over outward items, there was no correlation of any of the old/new ratios of the present experiments or the explicit familiarity ratings from Experiment 3a with previously obtained liking ratings of the same stimuli (Topolinski & Boecker, 2016a). Almost the exact same pattern was true for the correlations with fluency ratings, with the exception of the old/new ratios from Experiment 4, which did show a small correlation with fluency. Mediation analyses confirmed that neither liking nor fluency mediated the effect of consonantal direction on the different outcome variables. The absence of almost any correlation between both fluency and liking and the results from the recognition experiments could be due to task differences, with the current experiments using recognition paradigms whereas liking and fluency scores were obtained through explicit ratings; however, the fact that the measures of all four recognition experiments did indeed correlate significantly with the explicit familiarity from Experiment 3a renders this explanation very unlikely. The fact that liking and fluency ratings correlated significantly while neither correlated with familiarity ratings is another indicator that the finding cannot convincingly be explained by measurement errors or experimental differences, since all three ratings were based on the same scale and experimental procedure, only differing in the framing of the task. Rather, it seems that the observed familiarity effect in the current experiments occurs independently from the in-out preference effect previously demonstrated in the literature (Topolinski et al., 2014).

10.3 Experiment 9

A remaining concern might be that it is only the specific type of stimuli that was used in the recognition experiments that does not show a significant difference in fluency between inward and outward pseudo-words, and that the correlational pattern might turn out differently for another set of stimuli. Since I obtained familiarity ratings of another type of inward and outward pseudo-words framed as clothing brands in Experiment 3b, for which liking ratings could be retrieved from Topolinski and Boecker (2016a; Experiment 7), it is expedient to assess the subjective articulation fluency of these stimuli and test whether it differs for inward compared to outward stimuli, before again correlating them with liking and familiarity in Study 10 to see whether it confirms the findings from Study 8.

10.3.1 Method

Participants. N = 127 participants took part in the experiment. Data of one person was lost due to a computer system crash, and data of another participant had to be excluded because the person reported to be a native Italian speaker. This was relevant because the spelling of the pseudo-words is adapted to German, not Italian phonation, and some of the items could potentially resemble existing Italian words. The resulting sample therefore consisted of N = 125 participants (103 female, 22 male, mean age 22, SD = 4).

Materials and Procedure. The stimuli used in this experiment were the CVCV pseudo-words used in Experiment 3b, and the experimental procedure also closely followed Experiment 3b, with the difference that the pseudo-words were not framed as products which need to be rated on familiarity in this case. Instead, the 100 stimuli to be rated were presented as items in a pre-test and participants were simply asked to rate how hard or easy to pronounce each of the pseudo-words seemed to them on a scale from 0 = very hard to 10 = very easy, in line with Experiment 7.

10.3.2 Results

Of all raw trials, 11 (< 1 %) had to be discarded because participants had mistyped their response. A paired-samples t-test was run to compare the mean fluency ratings for inward and outward pseudo-words. Participants rated inward pseudo-words as easier to pronounce (M_{in} = 7.61) than outward pseudo-words (M_{out} = 7.55), but this difference was not statistically significant, $M_{\text{difference\_in-out}} = 0.06$, $t(124) = 1.68$, 95% $CI_{\text{difference}}$ [-0.01, 0.13], p = .096, $BF_{10} = 0.39$. On the item level, the difference between fluency ratings for inward compared to outward pseudo-words was not significant, $t(293) = 1.16$, 95% $CI_{\text{difference}}$ [-0.04, 0.16], p = .245, $BF_{10} = 0.24$. Figure 12 displays the mean fluency ratings by consonantal direction.

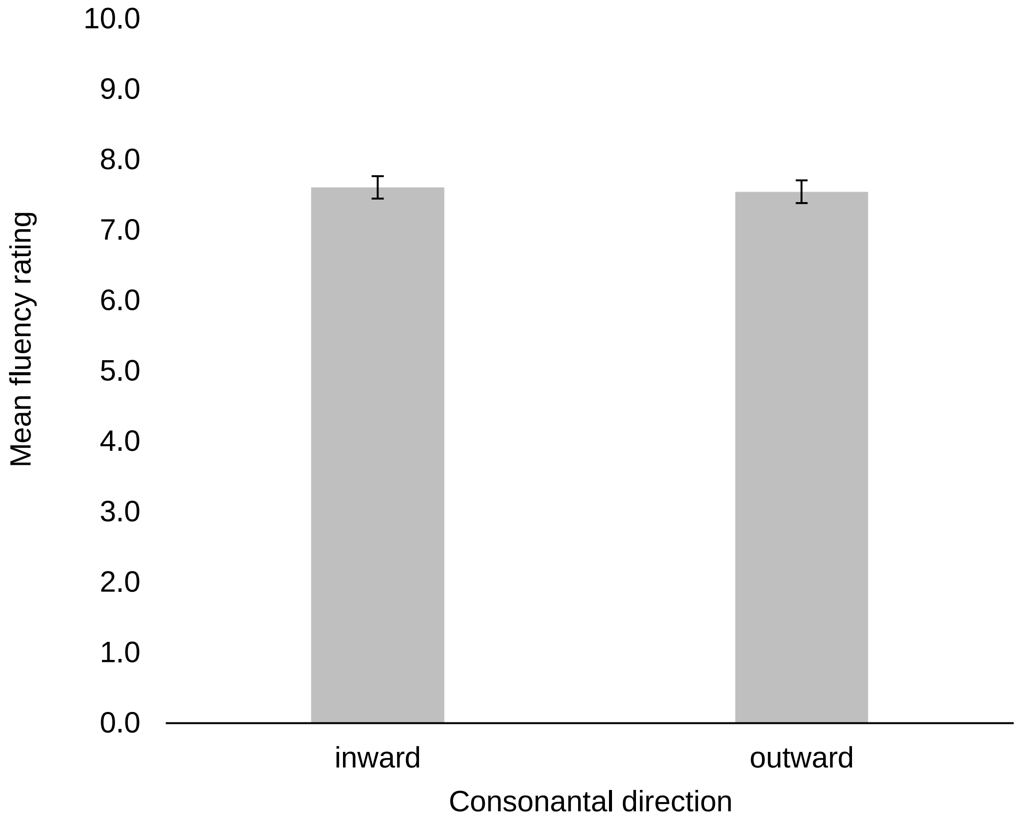


Figure 12: Mean articulation fluency ratings in Experiment 9 for inward and outward pseudo-words (error bars represent *SEM*s).

10.3.3 Discussion

Similarly to Experiment 7, there was a small difference in the subjective fluency ratings for inward compared to outward pseudo-words in the expected direction, but this difference was not significant. With mean ratings above seven, the stimuli were rated as generally easy to pronounce, which is to be expected for short four-letter pseudo-words with a simple consonant-vowel-consonant-vowel structure. Study 10 addresses potential correlations between fluency, liking and familiarity.

10.4 Study 10

The results of Study 8 showed familiarity differences between inward and outward pseudo-words to be independent from both liking and subjective articulation fluency of the respective stimuli. To see whether this finding would replicate in a different set of pseudo-words, a correlational analysis was conducted combining the fluency, familiarity, and liking ratings of the CVCV stimuli introduced in Experiment 3b.

10.4.1 Method

Ratings of familiarity on the item level for CVCV inward and outward pseudo-words were retrieved from Experiment 3b. Item fluency ratings were available from Experiment 9, and mean liking ratings for the items were calculated from raw data provided by Topolinski and Boecker (2016a, Experiment 7).

10.4.2 Results

Bivariate correlations were obtained for the three indices of familiarity, fluency, and liking. As can be seen in Table 2, there was again a significant correlation between liking and fluency (r = .30, p < .001), but not between liking and familiarity (r = .01, p = .832). Results also show a small significant correlation between fluency and familiarity (r = .12 p = .044).

Table 2:

Pearson correlation coefficients between liking ratings (Topolinski & Boecker, 2016a; Exp. 7), fluency ratings (Exp.9), and familiarity ratings (Exp. 3b).

	liking	fluency (Exp. 9)	familiarity (Exp. 3b)
liking	__	.295***	.012
fluency (Exp.9)		__	.117*
familiarity (Exp. 3b)			__

**** Pearson Correlation significant at p < .001*
*** Pearson Correlation significant at p < .01*
** Pearson Correlation significant at p < .05*

Mediation Analysis. A mediation analysis using a bootstrapping procedure (e.g., Hayes, 2013) with 5000 bootstrap samples again found no indirect effect of consonantal direction on familiarity; neither through liking (B = -0.003, SE = 0.03, 95 % CI [-0.06, 0.05]) nor fluency (B= 0.01, SE = 0.01, 95 % CI [-0.003, 0.06]).

10.4.3 Discussion

The results from Study 10 confirmed the findings of Study 8. Again, fluency and liking showed the strongest correlation, indicating that the in-out preference effect seems to be partially related to the higher subjective fluency of inward compared to outward pseudo-words (Bakhtiari et al., 2016). Liking did not correlate with familiarity, though, demonstrating again that the effect of consonantal direction on familiarity is not connected to a greater liking of inward compared to outward pseudo-words. There seems to be a small correlation between fluency and familiarity which was not significant for the VCVC stimuli used in Study 8, but is significant for the CVCV stimuli tested here. If there is such a connection between fluency and familiarity, it must be a direct link and cannot be mediated by liking due to the missing correlation between liking and familiarity. Given that the coefficient of r = .12 for the correlation between familiarity and fluency is very small, fluency could only constitute one component of the in-out familiarity effect, but is far from fully explaining the effect. This was confirmed by the mediation analysis, which did not find an indirect effect of consonantal direction on familiarity mediated by fluency. Consequently, there must be other factors contributing to the effect that I will address in the General Discussion.

Chapter 11 – General Discussion

The aim of the present work was to test the hypothesized effect of consonantal direction on familiarity. Several experiments tested and confirmed this hypothesis, ruled out alternative explanations of the effect, and examined potential underlying mechanisms. In this final chapter, I first summarize the results of the presented experiments and studies, and point out their limitations. Then, I discuss the results with respect to the possible mechanisms of the in-out familiarity effect. Finally, I present implications of the present findings regarding the role of affect in recognition memory, as well as potential applications of the in-out familiarity effect in the marketing context.

11.1 Summary of Results

The experiments reported in this work have demonstrated a memory bias for pseudo-words with an inward consonantal direction based on increased feelings of familiarity. Experiment 1 established this effect in a recognition task, finding higher hit and false alarm rates for consonantal inward compared to outward pseudo-words. This finding translated to a more liberal response bias for inward compared to outward pseudo-words in an SDT based analysis, while discriminability did not differ between the two types of consonantal direction. Experiment 2 underlined the robustness of this in-out familiarity effect by showing that it remained significant when the pseudo-words were paired with pictures and presented as products in a more marketing related context. In addition, Experiments 3a and 3b were able to demonstrate that inward pseudo-words presented as brand names were also explicitly judged to be more familiar than outward pseudo-words.

The alternative explanation of a general affirmation tendency elicited by inward compared to outward stimuli was ruled out by Experiment 4, which employed a Go/No-go paradigm to test whether inward pseudo-words would also lead to more frequent *old* judgments if those judgments had to be made by *not* responding to a stimulus. Results confirmed the prediction that the alternative explanation was not valid, showing that recognition judgments were based on the actual content of the response options instead of whether the response option required an affirmative or negative reaction.

Experiments 5 and 6 sought to answer the question whether the effect of consonantal direction on recognition was based on the familiarity component of memory alone, as suggested by the SDT analyses in Experiments 1, 2 and 4, or whether consonantal direction also influenced recollection. While the manipulation in Experiment 5 failed to eliminate the familiarity effect and therefore did not allow for the assessment of a separate recollection effect, the PDP in Experiment 6 made it possible to disentangle judgments based on familiarity from those based on recollection. As hypothesized, inward compared to outward consonantal direction in pseudo-words selectively increased familiarity, but not recollection.

To clarify the mechanism underlying the in-out familiarity effect, Experiment 7 assessed subjective articulatory fluency of the stimuli used in the recognition experiments. While there was a tendency of inward pseudo-words being rated easier to pronounce than outward pseudo-words, this difference was not significant, speaking against fluency as the (sole) mechanism underlying the familiarity effect. Combining the mean fluency ratings for each item with familiarity ratings and recognition ratios from the previous experiments, as well as with mean liking ratings from a previous publication (Topolinski & Boecker, 2016a), it was found in Study 8 that while liking and fluency were significantly correlated, neither of the two correlated with familiarity ratings or recognition ratios. Those recognition ratios and familiarity ratings, however, were significantly correlated across all experiments. Mediation Analyses showed that neither liking nor fluency mediated the effect of consonantal direction on the different familiarity and recognition measures. Experiment 9 and Study 10 confirmed the fluency finding as well as the correlational findings for the CVCV stimuli introduced in Experiment 3b, with the only difference that Study 10 found a small correlation between fluency and familiarity ratings. A mediation analysis again showed no mediation of the effect of consonantal direction on familiarity, neither by liking nor by fluency. Taken together, these findings suggest that a simple explanation based on a mediational effect of fluency or liking of a stimulus on its perceived familiarity does not seem to be able to account for the in-out familiarity effect presented in this work. This then raises the question what alternative mechanism might be responsible for the effect. Before discussing the possible mechanisms underlying the in-out familiarity effect, however, I want to briefly outline some limitations of the present experiments that are important to take into account in the interpretation and implications of the findings.

11.2 Limitations of the Present Experiments

There are certain limitations that should be discussed when interpreting the results of the experiments presented in this work. The first limitation concerns the applicability of the in-out familiarity effect in a marketing context. One might argue that the results of Experiment 2, while demonstrating the robustness of the effect in the presence of competing cues, are still based on the highly controlled paradigm of a recognition test. The limited exposure time, for example, is in contrast to the usual advertising context and especially a consumer context in which people can take their time to contemplate a purchase. Also, the recognition task presents all items sequentially; there is no option to compare items alongside each other, as would be the case when entering a shop in real life. The true benefit of applications of consonantal direction in the marketing context would therefore need to be explored in a field study. Experiment 2 provides a first step, however, in underlining the robustness of the in-out familiarity effect in the presence of other, more salient cues.

Another potential limitation might be the measurement of fluency in Experiments 7 and 9, which will be discussed in more detail in the following section on articulation fluency as a potential mechanism of the in-out preference effect. A subjective rating of articulation fluency was chosen because it elicited stronger effects than more objective measures of articulation and reading latency in a previous study on another set of stimuli (Bakhtiari et al., 2016), but it was apparently not sensitive enough to find differences between inward and outward consonantal direction in the sets of highly similar and easy to pronounce pseudo-words used in the present studies. Therefore, it is possible that a failure of the measure led to an underestimation of the role of articulatory fluency in the in-out familiarity effect, although the correlations with liking suggest that this explanation is unlikely (see section 11.3.1).

On a related matter, it can be criticized that the ratings that were being correlated in Studies 8 and 10 were all derived from different samples. Therefore, inter-individual differences between samples might have disturbed the correlations. The concern that certain ratings might consequently have been incomparable to each other can be somewhat dispelled by the finding that no rating or old/new ratio was completely uncorrelated: While all old/new ratios correlated with each other and familiarity ratings, liking and fluency were also significantly correlated. It is therefore unlikely that simple measurement errors or sample peculiarities could explain the pattern. It is possible, however, that correlations would have been higher between ratings derived from the same sample, which might be tested in future experiments. Such experiments, on the other hand, would need to be very carefully constructed to avoid confounding spillover effects, as they would be very likely to occur when the same stimuli are being rated for liking, fluency, and familiarity. Also, a study by Westerman, Lanska, and Olds (2015) demonstrated that when stimuli differing in fluency were rated for liking and familiarity in a within-subjects design, fluency only affected familiarity ratings, but there was no effect on liking, as is usually the case when fluency is manipulated. These results show that participants apparently adopted a single explanation for the perceived fluency, namely familiarity, which then nullified the effect on liking. It is therefore possible that the effect of consonantal direction would also only affect one of the concepts of liking, fluency, and familiarity, if they were tested in a within-subjects design. While it would be interesting to see which of the concepts would be the preferred interpretation, this would not provide useful estimates of the correlations between the liking, fluency, and familiarity effects, respectively.

11.3 The Mechanism behind the In-Out Familiarity Effect

What mechanism might drive the effect that inward consonantal direction in pseudo-words elicits higher perceived familiarity than outward consonantal direction? Research on the effect of consonantal direction on liking has already introduced two possible mechanisms that could explain the influence of consonantal direction: Firstly, approach-avoidance motivation (e.g., Topolinski et al., 2014), and secondly, (articulatory) fluency (Bakhtiari et al., 2016). I have discussed these two potential mechanisms in Chapter 3 and have outlined that more evidence has pointed towards the fluency account, at least regarding the effect on preference, which is why I chose to assess fluency as a potential mediator in Experiments 7 and 9, assuming that the effects of consonantal direction on familiarity might depend on the same mechanism as the effects on liking. Interestingly, the correlational studies in the present work showed that while the recognition judgments correlated with explicit familiarity ratings from Experiment 3a, they did not correlate with preference ratings from a recent paper (Topolinski & Boecker, 2016a). This suggests that these two effects of consonantal direction – familiarity and preference – occur independently from each other. Positive associations connected to inward consonantal patterns in comparison to outward patterns are therefore probably not responsible for increased perceived familiarity. The distinction of the two effects of consonantal direction indicates that they also might differ with respect to their underlying mechanisms. Addressing the potential mechanism behind the in-out familiarity effect may thereby in turn also provide new insights into the mechanism of the in-out preference effect in explaining the apparent independence of the two effects.

11.3.1 Articulatory Fluency

One possible mechanism underlying the in-out familiarity effect would be a higher articulatory fluency of inward pseudo-words (see articulation fluency, Alter & Oppenheimer, 2006). Previous research has shown that reading latency and subjectively rated fluency mediate the basic in-out preference effect, but only partially (Bakhtiari et al., 2016). However, recent research suggests that fluency might have a stronger impact on familiarity than on liking, when both are taken into account (Westerman, Lanska, & Olds, 2015). Therefore, I expected that articulatory fluency might be the driving mechanism of the in-out familiarity effect. Contrary to this prediction, fluency mostly did not correlate with familiarity in the present experiments, neither with familiarity ratings nor with recognition ratios, with the exception of two very small correlations with the old/new ratios of Experiment 4 in Study 8, and with familiarity ratings in Study 10. Also, the mediation analyses did not find any indirect effects of consonantal direction mediated by fluency on any of the outcome variables. In fact, in both Experiments 7 and 9 there was no significant difference in subjective articulatory fluency between inward and outward pseudo-words to begin with, but merely a tendency.

This could be an indicator that the subjective measure simply failed to find objective articulatory fluency differences between inward and outward consonantal patterns: By asking participants how easy each stimulus could be pronounced, I measured a subjective impression of articulation fluency. It is possible, though, that this subjective impression is not the best measure of fluency, and that this could be the reason why fluency did not correlate with familiarity and old/new ratios in Study 8. This is a valid concern; it needs to be noted, however, that this subjective measure derived from Bakhtiari et al. (2016) actually yielded much larger differences between inward and outward pseudo-words in that original study than a second, more objective measure. That second measure in the paper tested reading speed and also found a significant, but much smaller effect. Given that the stimuli in the present work are one syllable shorter that the stimuli used by Bakhtiari et al. (2016) and only involved two consonants, I did not expect to find any reliable reading speed differences for such extremely easy stimuli, as I described in the introduction of Experiment 7.

Of course it is also possible that the subjective measure employed in Experiments 7 and 9 did not only tap into articulatory, but also perceptual fluency. While there is no research suggesting why a stimulus such as IKOP should be less perceptually fluent than its inward counterpart IPOK, the presence of such an additional fluency effect would not challenge the present results of a missing correlation between fluency and the old/new ratios and familiarity ratings in Study 8; on the contrary, it would promote the interpretation that fluency does not seem to play a role in the in-out familiarity effect. Still, it is possible that the subjective rating of articulation fluency contained too much measurement error to capture actual differences in articulation fluency, which of course would have impaired the mediation analyses. Asking participants to rate words for ease of pronunciation has been successfully used to measure fluency in previous studies (e.g., Alter & Oppenheimer, 2006; Song & Schwarz, 2009), but in these studies stimuli were neither as easy to pronounce nor as similar to one another as in the present experiments. The measure might therefore not have been sensitive enough in the present case, perhaps because differences in articulation fluency were too subtle for participants to be able to consciously report them. While there is a chance that measurement error is responsible for the lacking mediation of the effect by fluency, it needs to be noted that the fluency ratings *did* indeed correlate with the liking ratings. This correlation might not have been large (r = .28 in Study 8; r = .30 in Study 10), but it fits the previous finding of a partial mediation of the in-out preference effect by fluency (Bakhtiari et al., 2016). This finding speaks against the concern that the subjective rating of pronunciation ease failed to capture articulation fluency altogether – rather, it seems as if it measured an experience of processing fluency that is at least partially relevant to liking ratings, but not to recognition judgments. What then could be the reason that liking and fluency of inward and outward pseudo-words are correlated, but neither is connected to familiarity and recognition?

A potential explanation is that when rating novel pseudo-words for valence, one might draw on associations with familiar names or real words and base the judgment of the pseudo-word on the valence of this associated word. To give a personal example, one item in the CVCV stimulus pool is BERI, which is not an existing word, but reminds me greatly of my own first name BERIT and is frequently used as a nickname by some friends. Therefore, as a participant I would rate this stimulus to be very positive because I associate it with endearment. To a certain degree, this is also true for the fluency ratings obtained in Experiments 7 and 9: If an association to a real word exists, the corresponding pseudo-word should appear more fluent, that is, easier to pronounce. When trying to remember words in a recognition test or rating pseudo-words presented as company or brand names for familiarity, however, drawing on such associations with real words would be counterproductive rather than helpful. That is because the participant needs to judge whether a *specific* pseudo-word was encountered before, and therefore should try to partial out any influences on the perception of the pseudo-word that are not related to previous experience with it. This could explain to some degree why fluency and liking ratings are correlated, while neither seems to be associated with familiarity in the present studies.

Apart from the possible role of associations to real words, it is also conceivable as mentioned above that the subjective ratings successfully measured articulation fluency (which simply did not differ greatly between stimuli), but that this articulation fluency selectively influences liking ratings, while it is not relevant to perceived familiarity. The role of articulation fluency for the in-out preference effect has been demonstrated in previous research (Bakhtiari et al., 2016), and is supported by the correlations I found between subjective articulation fluency and liking in Studies 8 and 10. Additionally, this assumption can also explain findings on modulations of the in-out preference effect, such as the slight preference of outward names for bubble gum, which is a positively evaluated product, but associated with an oral outward movement (Topolinski et al., 2017; Experiment 5). The articulation of an outward name therefore matches the oral affordances of bubble gum, making such a name more compatible or fluent than an inward name. However, there must be at least one additional mechanism underlying the effect of consonantal direction on liking as evidenced by the fact that articulation fluency did not fully mediate the effect (Bakhtiari et al., 2016) and that interfering with articulation simulations could not eliminate the effect (Lindau & Topolinski, 2016). This could be a different type of fluency unrelated to articulation and might be the crucial mechanism underlying the in-out familiarity effect which in the present experiments has appeared to be independent of liking and articulation fluency.

11.3.2 Frequency and Similarity to Real Words

Such an alternative mechanism of the in-out familiarity effect that is based on a fluency account could be that inward consonantal patterns might simply occur more frequently in natural language than outward consonantal patterns. As I briefly described in Chapter 3, Bakhtiari et al. (2016) already provided first evidence that this might be the case by showing front consonants to appear more frequently as the first consonant in a word and less frequently as the last consonant in a word compared to back consonants, both in a German and an English language corpus. This finding is rather preliminary, though, because the study did not take actual sequences of consonants into account, which are the basis for consonantal direction. Further studies comparing corpora from different languages and assessing them carefully for actual consonantal direction (rather than occurrence of single consonants at different places in a word) would be necessary to ascertain whether inward consonantal patterns are indeed more frequent in natural language than outward patterns.

Nevertheless, the preliminary findings suggest that there seem to be differences regarding the natural occurrence of inward and outward patterns which might in turn drive the effects observed in pseudo-words following the same patterns. Bakhtiari et al. (2016) argued that such a difference in frequency might be the reason for a greater articulatory fluency of inward compared to outward pseudo-words because the articulation of inward consonantal patterns could be better trained through more prevalent exposure in everyday speech. Indeed, Solomon and Postman (1952) already demonstrated in the 1950s that the recognition threshold for non-words decreased with increasing frequency of having pronounced those non-words in a study phase. However, it is also possible that a prevalence of inward words generally leads to higher processing fluency apart from actual articulation: For example, if certain sequences of phonemes are more frequent than others, this might also make them easier to process in their written form, meaning they become more orthographically or perceptually fluent.

This alternative explanation is supported by the fact that liking and familiarity effects of consonantal direction occur under silent reading, as well as by recent research on the in-out preference effect which demonstrated that the effect remained robust even when participants engaged in interfering oral motor tasks, such as chewing or concurrent articulation, which hindered covert articulation simulation (Lindau & Topolinski, 2016). With regard to other forms of processing fluency, manipulations of perceptual fluency have been shown to increase familiarity and recognition judgments (e.g., Johnston et al., 1985; Whittlesea et al., 1990; see also Reber & Zupanek, 2002, for effects of processing fluency on perceived frequency). Such influences on familiarity have been found especially for pseudo-words, because they provide no semantic meaning that could additionally influence the recognition process (Johnston et al., 1985). Ozubko and Joordens (2011) provided evidence that this lack of semantic meaning could be the reason for the so-called pseudo-word effect which describes the phenomenon of pseudo-words generally receiving higher hit and false alarm rates than real words: They argued that the missing semantic information presumably made it more difficult to distinguish between orthographically similar pseudo-words as compared to real words, and it seemed to be this higher similarity that increased familiarity judgments for pseudo-words. This assumption was supported by the findings that on the one hand, the pseudo-word effect disappeared when irregular pseudo-words were used (i.e., words dissimilar to real words), and on the other hand, real words of extremely high frequency (such as *and*, *them*, *this*) elicited a similar effect as regular pseudo-words, which was shown to be due to their low semantic distinctiveness compared to other real words (Ozubko & Joordens, 2011). These findings suggest another explanation of the in-out familiarity effect related to a potentially higher frequency of inward compared to outward consonantal patterns in natural language: Inward pseudo-words might simply be more *similar* to real words than outward pseudo-words. Hence, they should elicit stronger feelings of familiarity, resulting both in higher hit and false alarm rates, as observed in the present experiments.

In order to test this assumption, one would need to overcome the same difficulty that was described above in the context of subjective articulatory fluency: The pseudo-words for the present experiments were specifically created in a way that they are extremely similar to each other and only differ with respect to their consonantal and vocal direction; therefore ratings of similarity might result in ceiling effects that do not allow for a distinction regarding perceived similarity. An alternative approach could be to present the inward and outward pseudo-words under the pretense that half of them represented real words of an exotic language, while the other half was artificial, and to let participants rate the probability that a word was real. However, these judgments might in turn be influenced by feelings of familiarity or liking, thereby producing a circular argument. Another option would be to present a stimulus, for example IPOK, and to let participants choose whether this pseudo-word was more similar to a pseudo-word with reversed consonant order but intact vowel order (here, IKOP) or reversed vowel order but intact consonant order (here, OPIK). If the proportion of choices for pseudo-words with an intact consonant order would be higher for inward than for outward pseudo-words, this would suggest that inward consonantal direction might indeed lead to stronger perceived similarity.

11.3.3 Approach versus Avoidance Motivation

Apart from fluency and/or frequency accounts, an alternative idea might be that the approach versus avoidance motivation associated with oral inward versus outward movements (Topolinski et al., 2014) has a direct impact on familiarity, without mediation by liking. Research of approach and avoidance in the domain of memory has shown various effects of approach in contrast to avoidance motivation, for example that it can change declarative memory performance such as accuracy and learning rate (Murty, LaBar, Hamilton, & Adcock, 2011), lead to deeper processing of positive stimuli (Crowell & Schmeichel, 2016) and narrow attention, resulting in better memory performance for centrally as opposed to peripherally presented stimuli (Gable & Harmon-Jones, 2010). In an applied context, Sparks and Chung (2016) found both improved recall and recognition memory for advertisements in a video game under approach compared to avoidance motivation. Interestingly, the effects in these previous studies would mostly predict a better discriminability for approach related stimuli, which is at odds with my constant finding of increased hits *and* false alarms for inward compared to outward pseudo-words across the presented experiments. However, approach in contrast to avoidance motivation has also been shown to shift the focus of attention onto similarities rather than differences between objects (Nussinson, Seibt, Häfner, & Strack, 2011), which along with the similarity hypothesis described in the previous section might explain the higher false alarm rates for inward compared to outward pseudo-words I consistently found across the experiments. But can these approach-avoidance effects occur without the mediational role of liking of the stimuli?

As I discussed in subchapter 3.1.2, Krieglmeyer et al. (2010) demonstrated that two parallel mechanisms can elicit approach and avoidance responses when encountering valenced stimuli: When an evaluative goal is active (e.g., rating for valence), the evaluative consistency and common coding of a positively (negatively) labeled action and a positively (negatively) valenced stimulus facilitates this compatible response in comparison to an incompatible one. Independently of this evaluative coding effect, a positive (negative) stimulus should also evoke a motivational goal to approach (avoid) that target by reducing (increasing) one's distance to it. This motivation occurs automatically when encountering a stimulus of a certain valence; it does not need the goal to evaluate said stimulus (Krieglmeyer et al., 2010). Since the connection between target evaluation and approach/avoidance movements has been shown to be bidirectional (e.g., Cacioppo et al., 1993), one might argue that a bodily state or movement of approach or avoidance might also influence stimulus evaluations via two different parallel mechanisms: On the one hand, the associated valence of the movement (approach – positive; avoidance – negative) might influence perception of a stimulus as positive or negative through a common coding account. This should only be the case, however, when the goal to evaluate the stimulus is active, such as when people are asked to rate how much they like a stimulus. In parallel, the motivational orientation to reduce (increase) distance activated by approach (avoidance) movements might in itself influence perception of a target stimulus beyond the question whether it is positive or negative. This, for example, might be the case when the familiarity of a stimulus is in question. Positivity or negativity of the stimulus might not be the best indicator when trying to remember whether or not the stimulus had been encountered before – an experienced motivation to decrease or increase distance to it on the other hand might. In an evolutionary sense, familiarity serves as an indicator that one already had an experience with something and that it is safe, whereas something unfamiliar should induce caution (e.g., Bornstein, 1989; Hill, 1978; Bornstein et al., 1987). It is important to state that I do not assume this motivation to be free of positive affect; I do, however, suggest that it can be independent of the explicit "liking" of a stimulus in response to an evaluative goal. The discreteness of the in-out preference effect and the in-out familiarity effect found in the present studies could therefore be explained by two different mechanisms being at work, with the preference effect drawing on the evaluative component and the familiarity effect drawing on the motivational component of the approach versus avoidance movements elicited by inward versus outward stimuli, respectively.

These presumed differential effects of an evaluative coding versus a motivational account are difficult to test in the case of consonantal direction, however. The inward and outward oral movements cannot simply be re-labeled in the way that arm movements of extension can for example be framed as either pushing away or reaching for something, and arm movements of flexion can be framed as either pulling towards or withdrawing from something. In fact, the inward and outward oral movements caused by consonantal direction do not need to be labeled at all, and participants are not even aware that differential oral movements are elicited by the target stimuli (see Topolinski et al., 2014). Also, the oral movement is inherent to the tested stimuli; it is not an oral "response" that could be altered by instruction. For now, therefore, the potential explanation of two distinct approach-avoidance mechanisms being responsible for the in-out preference and the in-out familiarity effect remains speculative.

11.4 Implications for the Role of Affect in Recognition Memory

Beyond the question of possible mechanisms responsible for the differential effects of consonantal direction, the findings presented in this work also provide new insights into the role of affect in recognition memory in general. A number of studies have demonstrated effects of positivity on familiarity (e.g., Garcia-Marques et al., 2004; Monin, 2003) and vice versa (e.g., Garcia-Marques et al., 2010). The general idea here is that something familiar usually feels safe and positive, so positive affect might in turn serve as a cue of familiarity (e.g., Garcia-Marques et al., 2004; Monin, 2003). But what does it mean when something becomes "familiar"? Research on recognition memory has suggested that exposure to a stimulus strengthens representations of its features in memory, thereby leading to more fluent subsequent processing of the stimulus, which is responsible for the perception of familiarity (e.g., Johnston et al., 1985; Mandler, 1980). This assumption has been supported by findings that superficial perceptual fluency of stimuli can elicit similar effects on familiarity (e.g., Jacoby & Dallas, 1981; Thapar & Westerman, 2009). Because processing fluency has been shown to almost universally produce liking and positive affect (e.g., Reber et al., 1998; Winkielman & Cacioppo, 2001), this has led researchers to assume that fluency might be hedonically marked, that is, inherently associated with positive affect (Winkielman et al., 2003; see also Reber et al., 2004; Claypool et al., 2015). This is very much in line with Zajonc's original account of the mere exposure effect, who claimed that the repeated exposure of a stimulus directly evoked positive affect, without mediating cognitive inferences (e.g., Zajonc, 1968, 1980, 1984; Kunst-Wilson & Zajonc, 1980). This assumed primacy of affect suggests that positive affect should mediate the effect of fluency on perceived familiarity (see Phaf & Rotteveel, 2005, who showed influences of affective primes on recognition bias).

Contrary to that hypothesis, I did not find any relation between the liking of inward and outward pseudo-words and their perceived familiarity measured by subjective ratings and recognition test outcomes in Studies 8 and 10 of the present work. Of course one might argue that an affective response elicited by inward versus outward consonantal direction must not translate perfectly into liking ratings of the respective pseudo-words. However, even if one allows for measurement errors and additional influences on liking (such as associations to real words, see 11.3.1), at least a moderate or even small correlation between liking ratings and familiarity outcomes should be expected. This was not the case in either of the present correlational studies. While these findings are at odds with previous assumptions on the role of affect in recognition memory (e.g., Phaf & Rotteveel, 2005; Rotteveel & Phaf, 2007), they are actually in line with more recent research in this field: As described above, Westerman, Lanska, and Olds (2015) were the first to assess the effects of processing fluency on both liking *and* familiarity within the same experiment in a recent study, and found that when both concepts are assessed, fluency only influenced familiarity, but not liking. The authors argued that participants seemed to prefer a single explanation for the perceived fluency – the fact that they chose familiarity rather than liking challenges the hedonic marking hypothesis of fluency with its underlying assumption of a primacy of affect (Westerman, Lanska, & Olds, 2015).

Similarly, a recent study showed that the generally higher false alarm rates elicited by positive compared to negative stimuli in recognition tests (e.g., Ohira, Winton, & Oyama, 1998; Ortony, Turner, & Antos, 1983; Robinson-Riegler & Winton, 1996) could be explained by the higher inter-stimulus similarity among positive compared to negative words, rather than by their respective valence (Alves et al., 2015). The idea of a higher similarity among different positive stimuli than among different negative stimuli is based on the density hypothesis (Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008), which states that positive information is generally more similar than negative information; a claim that has since been shown for several different types of valenced stimuli and that might account for a number of effects previously attributed to affective responses elicited by positive versus negative stimuli (e.g., Alves, Koch, & Unkelbach, 2017; Koch, Alves, Krüger, & Unkelbach, 2016; Unkelbach, 2012). To give an example, Monin (2003; Experiment 3) presented the finding that the same moderately attractive faces evoked lower or higher familiarity when they were contrasted with more or less attractive faces, respectively, as evidence that it was actual attractiveness (i.e., valence) rather than prototypicality of the individual faces that had an impact on familiarity. However, an alternative explanation is that by choosing a more or less attractive face as a contrast, Monin actually provided a more or less *distinctive* face as a comparison (see Potter, Corneille, Ruys, & Rhodes, 2007, on the higher similarity among attractive vs. unattractive faces), which would suggest that the increased familiarity was based on higher perceived similarity, rather than valence.

As I described above, one of the possible explanations of the in-out familiarity effect introduced in the present work is that inward consonantal patterns could be more frequent in natural language than outward patterns, which would render inward pseudo-words more similar to real words and therefore easier to process. Taken together with the findings that liking of the pseudo-words did not mediate any of the presented effects on familiarity, further research on the mechanism of the in-out familiarity effect might also add to the recent research investigating the affective versus cognitive processes involved in recognition memory.

11.5 Potential Applications in the Marketing Context

In addition to the new insights and questions regarding the mechanisms behind effects of consonantal direction, the familiarity effect as I found it in the present experiments also entails fascinating opportunities for marketing applications. Being able to design brand or product names that have an inherent advantage in eliciting feelings of familiarity in potential customers without any prior exposure by this simple manipulation would be an efficient marketing strategy (see Lowrey, Shrum, & Dubitsky, 2003, for other effects of linguistic properties on brand name memorability). Making a brand or product more familiar is usually the aim of advertising strategies seeking frequent repetition and wide-spread presentation, for example in print and television. These strategies involve high costs because expensive air time and print space has to be bought. Of course a superficial effect of consonantal direction of a brand or product name could not replace those advertising strategies, but it might boost their effectiveness. In a supermarket, for example, where many products of the same kind are usually presented alongside each other on a shelf, a pleasant and familiar sounding product name might be an advantage that could lead to more frequent choice of the product and higher willingness-to-pay.

Effects in that direction have already been demonstrated by Topolinski et al. (2015), who found that people were willing to pay significantly more for products with inward compared to outward names, with differences of up to 13%, which is quite substantial for such a subtle manipulation of the names. The findings of Experiment 2 in the present work suggest that this effect should even persist in the presence of other salient cues such as product pictures. Furthermore, having expanded the effects of inward/outward consonantal patterns beyond preference, further effects become conceivable: For example, the higher perceived familiarity might also lead to higher trust in brands, products, or even people with inward names. A current line of studies also investigates whether the higher familiarity of inward compared to outward brand names might be disadvantageous in some instances, for example when a brand is supposed to be especially exclusive or innovative and therefore new and uncommon rather than familiar, or whether the greater liking of inward consonantal direction trumps this effect (Lindau & Topolinski, 2017). These and further potential applications of the effect should be tested in the field to investigate the external validity of the findings of laboratory studies.

11.6 Conclusion

Taken together, the presented findings of a substantial, robust familiarity effect of inward compared to outward pseudo-words that is independent from preference shows that the cognitive mechanisms and consequences of the effects of consonantal directions are by no means fully explored yet. The results suggest that there might be two independent mechanisms underlying the in-out preference and the in-out familiarity effect. While the correlations of subjective articulation fluency and liking indicate that articulation fluency might play a role in the in-out preference effect, as found by previous studies (Bakhtiari et al., 2016), this does not seem to be the case for the in-out familiarity effect. A different type of processing fluency, based for example on a higher similarity of inward rather than outward pseudo-words to real words, might instead be responsible for the effect of consonantal direction on familiarity. Alternatively, it is conceivable that differential effects of approach and avoidance influence the two effects of consonantal direction. Further research is needed to clarify the apparent distinction between the effect of consonantal direction on familiarity and liking by dissociating their underlying mechanisms. Given how subtle the differences between the inward and outward pseudo-words are, especially in the stimuli used in the current study, the consistency of the effects across experiments is quite fascinating, and the origins of the phenomenon deserve further study.

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Appendix A

List of VCVC stimuli used in Experiments 1, 2, 3a, 4, 5, 6, and 7:

Pseudo-words for which vowels move inwards and consonants move inwards:
EBOG, EBOK, EBOR, EBUG, EBUK, EBUR, EMOG, EMOK, EMOR, EMUG, EMUK, EMUR, EPOG, EPOK, EPOR, EPUG, EPUK, EPUR, IBOG, IBOK, IBOR, IBUG, IBUK, IBUR, IMOG, IMOK, IMOR, IMUG, IMUK, IMUR, IPOG, IPOK, IPOR, IPUG, IPUK, IPUR

Pseudo-words for which vowels move outwards and consonants move inwards:
OBEG, OBEK, OBIG, OBIK, OBIR, OMEG, OMEK, OMER, OMIG, OMIK, OMIR, OPEG, OPEK, OPIG, OPIK, OPIR, UBEG, UBEK, UBER, UBIG, UBIK, UBIR, UMEG, UMEK, UMER, UMIG, UMIK, UMIR, UPEG, UPEK, UPER, UPIG, UPIK, UPIR

Pseudo-words for which vowels move inwards and consonants move outwards:
EGOB, EGOM, EGOP, EGUB, EGUM, EGUP, EKOB, EKOM, EKOP, EKUB, EKUM, EKUP, EROB, EROM, EROP, ERUB, ERUM, ERUP, IGOB, IGOM, IGOP, IGUB, IGUM, IGUP, IKOB, IKOM, IKOP, IKUB, IKUM, IKUP, IROB, IROM, IROP, IRUB, IRUM, IRUP

Pseudo-words for which vowels move outwards and consonants move outwards:
OGEB, OGEM, OGEP, OGIB, OGIM, OGIP, OKEB, OKEM, OKEP, OKIB, OKIM, OKIP, OREB, OREM, OREP, ORIB, ORIM, ORIP, UGEB, UGEM, UGEP, UGIB, UGIM, UGIP, UKEB, UKEM, UKEP, UKIB, UKIM, UKIP, UREB, UREM, UREP, URIB, URIM, URIP

List of CVCV stimuli used in Experiments 3b and 9:

Inward:
BAGE, BAGI, BAGO, BAGU, BAKI, BAKO, BAKU, BARI, BARO, BARU, BEGA, BEGI, BEGO, BEGU, BEKA, BEKI, BEKO, BEKU, BERA, BERI, BERO, BERU, BIGA, BIGO, BIGU, BIKA, BIKO, BIKU, BIRA, BIRO, BIRU, BOGA, BOGI, BOGU, BOKA, BOKE, BOKI, BOKU, BORE, BORI, BORU, BUGE, BUGI, BUGO, BUKA, BUKE, BUKI, BURA, BURI, BURO, MAGO, MAGU, MAKO, MAKU, MARO, MARU, MEGO, MEGU, MEKI, MEKO, MEKU, MERA, MERI, MERO, MERU, MIGA, MIGE, MIGO, MIGU, MIKA, MIKO, MIKU, MIRE, MIRO, MIRU, MOGA, MOGE, MOGI, MOGU, MOKE, MOKI, MOKU, MORA MORI, MORU, MUGA, MUGE, MUGI, MUGO, MUKA, MUKE, MUKO,

MURA, MURE, MURI, MURO, PAGI, PAGO, PAGU, PAKE, PAKI, PAKO, PAKU, PARE, PARI, PARO, PARU, PEGA, PEGO, PEGU, PEKI, PEKO, PEKU, PERA, PERI, PERO, PIGA, PIGE, PIGO, PIGU, PIKA, PIKO, PIKU, PIRA, PIRE, PIRO, PIRU, POGA, POGI, POGU, POKA, POKI, POKU, PORA, PORI, PORU, PUGA, PUGE, PUGI, PUGO, PUKA, PUKI, PUKO, PURA, PURI, PURO

Outward:

GABO, GABU, GAMI, GAMO, GAMU, GAPE, GAPI, GAPO, GAPU, GEBA, GEBI, GEBO, GEMI, GEMO, GEMU, GEPA, GEPI, GEPO, GEPU, GIBA, GIBE, GIBO, GIBU, GIMA, GIME, GIMO, GIMU, GIPA, GIPE, GIPO, GIPU, GOBA, GOBE, GOBU, GOME, GOMU, GOPE, GOPU, GUBA, GUBE, GUBI, GUBO, GUMA, GUME, GUMO, GUPA, GUPE, GUPI, GUPO, KABE, KABI, KABO, KABU, KAME, KAMI, KAMO, KAMU, KAPE, KAPI, KAPO, KAPU, KEBA, KEBI, KEBO, KEBU, KEMA, KEMI, KEMO, KEMU, KEPA, KEPI, KEPO, KEPU, KIBE, KIBO, KIBU, KIMA, KIME, KIMO, KIMU, KIPA, KIPO, KIPU, KOBA, KOBI, KOBU, KOME, KOMU, KOPE, KOPU, KUBE, KUBI, KUBO, KUMA, KUME, KUMI, KUMO, KUPA, KUPE, KUPI, KUPO, RABO, RABU, RAME, RAMI, RAMO, RAMU, RAPI, RAPO, RAPU, REBA, REBI, REBO, REBU, REMA, REMI, REMO, REMU, REPA, REPI, REPO, REPU, RIBA, RIBE, RIBO, RIBU, RIMA, RIMO, RIMU, RIPA, RIPE, RIPO, RIPU, ROBA, ROBU, ROMU, ROPU, RUBA, RUBE, RUBI, RUBO, RUMA, RUME, RUMI, RUMO, RUPA, RUPE, RUPI, RUPO

Appendix B

Table 3:

Parameters for random and fixed effects of the GLMM on the data of Experiment 1.

Effects	**Parameters**			
Random effects	***SD***			
Items				
Intercept	0.41			
Participants				
Intercept	0.64			
Consonantal Direction	0.43			
Fixed effects	χ^2	***p***	***OR***	**CI**
Exposure status	13.57	< .001	1.20	[1.09, 1.33]
Consonantal direction	15.69	< .001	1.47	[1.22, 1.77]
Exposure status*Consonantal direction	0.18	.674	0.96	[0.79, 1.17]

Table 4:

Parameters for random and fixed effects of the GLMM on the data of Experiment 2.

Effects	**Parameters**			
Random effects	***SD***			
Items				
Intercept	0.24			
Participants				
Intercept	0.75			
Consonantal Direction	0.40			
Fixed effects	χ^2	***p***	***OR***	**CI**
Exposure status	29.93	< .001	1.30	[1.18, 1.42]
Consonantal direction	15.00	< .001	1.34	[1.16, 1.54]
Product type	32.97	< .001		
Chocolates vs. others	z = 4.98	< .001	1.18	[1.11, 1.26]
Cheese vs. gummy bears	z = 2.89	.004	1.19	[1.06, 1.33]
Exposure status*Consonantal direction	2.88	.090	1.18	[0.98, 1.42]
Exposure status*Product type	0.88	.645		
Exposure status*Chocolates vs. others	z = -0.14	.892	0.99	[0.87, 1.13]
Exposure status*Cheese vs. gummy bears	z = -0.93	.353	0.90	[0.71, 1.13]
Consonantal direction* Product type	0.84	.656		
Consonantal direction* Chocolates vs. others	z = 0.91	.362	1.06	[0.93, 1.21]
Consonantal direction* Cheese vs. gummy bears	z = -0.12	.908	0.99	[0.78, 1.24]
Exposure status*Consonantal direction*Product type	2.40	.301		
Exposure status*Consonatal direction*Chocolates vs. others	z = 1.20	.231	1.17	[0.90, 1.53]
Exposure status*Consonatal direction *Cheese vs. gummy bears	z = 1.00	.320	1.26	[0.80, 2.00]

Table 5:

Parameters for random and fixed effects of the LMM on the data of Experiment 3a.

Effects	**Parameters**				
Random effects	***SD***				
Items					
Intercept	0.17				
Participants					
Intercept	1.77				
Consonantal Direction	0.14				
Fixed effects	***F***(1, 72.94)	***p***	***B***	***SE***	**CI**
Consonantal direction	6.14	.016	0.14	0.06	[0.03, 0.25]

Table 6:

Parameters for random and fixed effects of the LMM on the data of Experiment 3b.

Effects	**Parameters**				
Random effects	***SD***				
Items					
Intercept	0.15				
Participants					
Intercept	1.72				
Consonantal Direction	0.16				
Fixed effects	***F***(1, 80.32)	***p***	***B***	***SE***	**CI**
Consonantal direction	5.36	.023	0.09	0.04	[0.01, 0.17]

Table 7:

Parameters for random and fixed effects of the GLMM on the data of Experiment 4.

Effects	**Parameters**			
Random effects	***SD***			
Items				
Intercept	0.37			
Exposure status	0.31			
Participants				
Intercept	0.47			
Consonantal Direction	0.30			
Fixed effects	χ^2	***p***	***OR***	**CI**
Exposure status	20.13	< .001	1.29	[1.16, 1.43]
Consonantal direction	19.21	< .001	1.45	[1.24, 1.71]
Instruction	16.21	< .001	1.51	[1.25, 1.84]
Exposure status*Consonantal direction	0.87	.350	1.11	[0.90, 1.37]
Exposure status*Instruction	0.30	.586	1.05	[0.87, 1.27]
Consonantal direction* Instruction	0.06	.804	0.97	[0.78, 1.21]
Exposure status*Consonantal direction*Instruction	0.47	.494	0.88	[0.61, 1.27]