Short Research Article

# Disfluent, But Fast

## Inverted-U Shaped Effect of Fluency on Decision Times

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**Abstract:** Processing fluency, a metacognitive feeling of ease of cognitive processing, serves as a cue in various types of judgments. Processing fluency is sometimes evaluated by response times, with shorter response times indicating higher fluency. The present study examined existence of the opposite association; that is, it tested whether disfluency may lead to faster decision times when it serves as a strong cue in judgment. Retrieval fluency was manipulated in an experiment using previous presentation and phonological fluency by varying pronounceability of pseudowords. Participants liked easy-to-pronounce and previously presented words more. Importantly, their decisions were faster for hard-to-pronounce and easy-to-pronounce pseudowords than for pseudowords moderate in pronounceability. The results thus showed an inverted-U shaped relationship between fluency and decision times. The findings suggest that disfluency can lead to faster decision times and thus demonstrate the importance of separating different processes comprising judgment when response times are used as a measure of processing fluency.

**Keywords:** fluency, liking, recognition, response times, pronounceability, judgment

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Processing fluency, a metacognitive feeling of ease of cognitive processing, can take many different forms (Alter & Oppenheimer, 2009). Depending on a cognitive process, people may feel, for example, perceptual fluency as a result of a high figure-ground contrast (Reber, Winkielman, & Schwarz, 1998), phonological fluency as a result of good pronounceability (Bahník & Vranka, 2017), or retrieval fluency as a result of fast recollection of memories (Winkielman, Schwarz, & Belli, 1998). It has been argued that a common feeling of fluency arises from a combination of these various forms of fluency (Alter & Oppenheimer, 2009). This feeling of fluency can then in turn be used as a cue in judgment. Consequently, different forms of fluency usually lead to the same judgmental effects. For example, various manipulations of fluency lead to higher frequency estimates, perceived familiarity, and positive evaluation (Alter & Oppenheimer, 2009).

Subjective feeling of processing fluency is influenced by the speed of the cognitive process (Reber, Wurtz, & Zimmermann, 2004). For example, easily pronounceable words might elicit a feeling of fluency because they are pronounced relatively fast. Consequently, response times have been sometimes used as a measure of processing fluency (e.g., Owen, Halberstadt, Carr, & Winkielman, 2016; Thomas & Morwitz, 2009; Unkelbach, 2007; Unkelbach & Rom, 2017; Winkielman, Olszanowski, & Gola, 2015). While response times may often be useful for assessment of processing fluency, it is necessary to take into account that response times usually do not measure speed of a single process and fluency may differ between processes that comprise the response. For example, a judgment of liking of a word can be divided to the reading of the word and its subsequent evaluation.[1] The fluency of these two processes can differ: a hard-to-pronounce word may be read with difficulty, but its evaluation (i.e., a decision[2] whether one likes the word, or not) might be easy because the disfluent pronunciation can serve as a strong cue for disliking. If decision-making is not separated from reading, response times may paint a misleading picture about fluency of the two processes.

This problem can be seen, for example, in a recent study by Unkelbach and Rom (2017). Unkelbach and Rom wanted to rule out fluency as an explanation for an effect of repetition on judgment of truth. They found that one of their experimental manipulations led to lower perceived

[1] These two processes are not singular processes as well, and it would be possible to divide them further into their constituting processes.

[2] While judgment and decision are often used interchangeably, “decision” is reserved here for the choice between possible answers and “judgment,” as used here, comprises two phases: obtaining information (e.g., reading a sentence or a word) and the resulting decision. Decision time thus refers specifically to the time needed to choose an answer and judgment time includes the time required for processing stimuli as well.

truth and faster judgments. Because fluent stimuli are usually associated with shorter response times, but *higher* perceived truth, Unkelbach and Rom argued that fluency did not mediate the effect of the manipulation on truth judgments. However, the assumption that faster response times indicate fluent processing of stimuli would hold only if the response times did not also include the time needed to reach the decision about truth of the evaluated sentences. Given that Unkelbach and Rom measured both reading and decision times together, it is possible that the manipulation led to slower, more disfluent reading of the sentences, but the decision process was then faster, because this disfluency served as a strong cue for judgment of truth. Therefore, the pattern of results observed by Unkelbach and Rom still can be explained by the use of fluency of stimuli in judgment of truth, contrary to their conclusion.

Even though the theoretical distinction between fluency of obtaining information and decision fluency suggests potential problems of existing studies that use response times to measure fluency, there has not been a study, which would clearly separate the two constructs empirically. The present study, therefore, tried to separate the decision process from the preceding process of obtaining cues for the decision (in this case reading).

The study used two manipulations of fluency. Participants were presented pseudowords that varied in their pronounceability (*phonological fluency*) and that were either shown previously, or not (*retrieval fluency*).[3] Furthermore, the study used two types of judgments. Participants had to decide whether they had seen a pseudoword before or whether they like it. Importantly, they had not known during reading of the pseudowords which question they were going to answer and which answer was going to be assigned to which key. Moreover, the pseudoword disappeared once participants indicated that they had read it. Consequently, they could not have easily prepared the answer during the reading and the processes of reading and decision-making were thus separated in the task. It was therefore possible to assess the effect of fluency of stimuli on response times for the two processes separately. I expected that processing fluency manipulated by both previous presentation and varying pronounceability of pseudowords would lead to faster response times for reading of the pseudowords, following the usual association of fluency with faster processing. On the other hand, I expected that pronounceability would have an inverted-U shaped relationship with decision times.

The expected relationship of fluency and decision times can be understood intuitively by the observation that it generally takes people longer to decide when they vacillate between two options. When there is a strong reason to decide for one of the options, it is easily chosen and the decision does not have to take much time. In case of judgment of liking of pseudowords, a reason for liking a pseudoword might be that it is easy to pronounce and a reason for disliking a pseudoword might be that it is difficult to pronounce. When the pseudoword is moderate in pronounceability, there is no strong reason to decide either way, and the person has to search for other reasons to decide whether she likes the word, or not. The decision is therefore slower. More formally, this process can be described from the perspective of the diffusion decision model (Ratcliff, Smith, Brown, & McKoon, 2016; Voss, Nagler, & Lerche, 2013). According to the diffusion model, decision-making can be viewed as a process of noisy accumulation of evidence. The diffusion model states that a decision is made when the decision maker accumulates enough evidence to pass a certain threshold. The average rate of accumulation of evidence is determined by the so-called drift rate, which determines which of the options tends to be favored by the evidence. For evaluation of a pseudoword in terms of liking, the drift rate is influenced by various features of the stimulus. The feature that is of interest for the present study is processing fluency (viz., pronounceability). Importantly, holding other variables in the diffusion model constant, the drift rate influences not only the probability of the "like" and "dislike" responses, but also the time needed to reach the decision. For example, if it is easy to find reasons for liking a certain pseudoword, people will tend to decide fast that they like the pseudoword. If the same amount of evidence is required for both "like" and "dislike" answers and the decision maker is not strongly biased toward any of the answers by default, the higher the absolute value of the drift rate, the higher the probability of a given response is and the faster the decision will be made. As long as the drift rate ranges from negative to positive values based on the level of fluency – that is, if fluency generally influences the drift rate toward positive values (i.e., toward the option "like") and disfluency toward negative values (i.e., toward the option "dislike") – the diffusion model predicts the inverted-U shaped relationship between fluency and decision times.[4] Given that previous presentation has only two possible values (either presented previously, or not), there is no clear prediction of the effect of previous presentation on decision times. The drift rate associated with previous presentation might have a lower, same, or higher absolute value than the less positive drift rate for pseudowords not presented previously, depending

[3] Previous presentation does not manipulate only retrieval fluency. People may base their recognition judgment on felt familiarity as well. In the present study, previous presentation serves mainly as a means to introduce the recognition judgment in the experiment, which enables separation of the two judgmental processes.

[4] If people, for example, tended to predominantly answer that they like the pseudowords, strong disfluency could lead to hesitation rather than to a relatively easy decision that one does not like the pseudoword.

on whether the drift rates are both negative, one positive and one negative, or both positive.

The main goal of the study was to show that reading and decision processes can be separated and that the same fluency manipulation may lead to different effects on speed of the two processes. The study tested the following hypotheses: Given that fluency of a process is often evaluated by response times, I expected that previously presented pseudowords as well as easily pronounceable pseudowords will be associated with shorter reading times (H1a and H1b). As in previous research (Laham, Koval, & Alter, 2012; Zajonc, 1968), I expected to find a positive association between previous exposure as well as pronounceability and liking (H2a and H2b). Furthermore, I expected that participants will be more likely to say that easy-to-pronounce words were previously presented, because fluency is usually associated with familiarity and disfluency with novelty (H3; Bahník & Vranka, 2017; Whittlesea, Jacoby, & Girard, 1990).[5] Of primary interest, I expected to find an inverted-U shaped relationship between pronounceability and liking decision times (H4) and between pronounceability and recognition decision times (H5). H4 assumed that pronounceability influences liking (H2b) and H5 assumed that pronounceability influences judgment of recognition (H3) because pronounceability can lead to the predicted inverted-U shaped relationship only when fluency is used as a cue in judgment. Given that H3 was not supported, H5 cannot be taken to properly test the predicted consequence of disfluency.

## Method

The materials, analysis scripts, and data can be found on https://osf.io/9fxeh/

### Participants

Two hundred participants (84.5% university students; 89% right handed, $Mdn_{\text{age}}$ = 23) participated in the study, which was administered as the first experiment in a larger set of studies.

### Procedure

The experiment consisted of two parts; both administered on a computer using a custom written Python program (see Figure 1 for schema of the experiment). First, participants read sequentially presented, randomly selected 40 pseudowords (e.g., inptagzakr, aktenmiatz, deseizurrz; henceforth "words" for simplicity; for details, see Stimuli below), each for 1 s (with an interstimulus interval of 500 ms). The second part consisted of 80 trials. During each trial, participants first saw a word and responded by pressing the spacebar once they read it. Half of the words had been shown in the first part of the experiment. Afterward, the word disappeared and participants were offered one of two possible pairs of answers – either "like" and "dislike," or "seen" and "not seen." The answers determined if they should reply whether they like the word or whether they saw the word during the first part of the experiment. The answers were shown on the left and right side of the screen and corresponding keys ("S" on left and "K" on right) were shown below them. The pair of answers as well as their sides were randomly determined for each trial. Therefore, participants could not easily prepare the answer while reading the word because they did not know the question that they were going to be asked and which key was going to correspond to their preferred answer. After each trial, before presentation of the next word, an intertrial interval of 250–750 ms (randomly determined) followed. Participants were instructed to respond as fast as possible both after reading the word and when answering the question related to the word. They were also instructed to try to use both "like" and "dislike" options and they were told that they had seen half of the words during the first part of the experiment. Before the main experiment, participants practiced the procedure in 10 trials with 5 previously presented words.

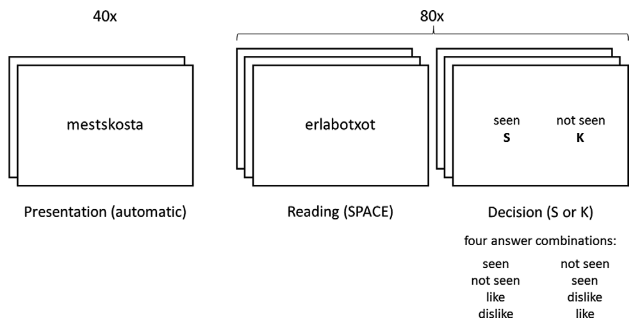


**Figure 1.** A schema of the experimental procedure. Participants were first sequentially presented 40 words. The next part of the experiment consisted of 80 trials. As a part of each trial, participants were first shown a word (half of the words had been presented before). After indicating that they read the word by pressing SPACE, participants were asked to decide whether they had seen the word or whether they liked the word. The answers were randomly assigned to "S" and "K" keys on each trial.

### Stimuli

I used a list of 130 ten-letter-long pseudowords as stimuli. The words were randomly constructed such that they were

[5] In an exploratory analysis, I also examined whether pronounceability influences correctness of recognition. The results are reported on https://osf.io/3zd62/wiki/home/

not familiar to the participants and that they varied in pronounceability. For example, words “asnskntxzk” and “ngenttzaek” were the hardest to pronounce; “ooeleginea” and “rarrriazio” were in the middle according to pronounceability; and “lanomeltap” and “kondrimial” were the easiest-to-pronounce words. For details of the word construction see https://osf.io/5m6pa/wiki/. The same ten words were always used for the practice session. Out of the remaining 120 words, each participant received 80 randomly selected words during the experimental part of the study. After completing unrelated studies, each participant rated 25 words out of the remaining words in terms of their pronounceability on a scale from 1 (= *hard to pronounce*) to 7 (= *easy to pronounce*) and 15 words in terms of whether they believe that they exist in some world language on a scale from 1 (= *surely does not exist*) to 7 (= *surely exists*). The average ratings of words in these two measures correlated highly, $r(118) = .83$, 95% CI [0.77, 0.88], $p < .001$. I therefore used in subsequent analyses only pronounceability, which has been often equated with fluency, the primary topic of the study.

## Analysis

All analyses were done with mixed-effect models and generalized mixed-effect models (Baayen, Davidson, & Bates, 2008; Gelman & Hill, 2007) using R library lme4 (Bates, Maechler, Bolker, & Walker, 2015). I used in total five dependent variables: reading time, liking, recognition, liking decision time, and recognition decision time. For the response time dependent variables, I used their logarithms in all analyses. The log-transformation led to distributions close to normal. (Descriptive statistics were computed using non-transformed response times.) I also removed outlying trials that had response times three or more standard deviations from the mean computed across all participants. For all dependent variables, I further excluded trials on which reading time was three or more standard deviations below the mean (less than 217 ms) because I assumed that participants could not have read the words properly on these trials. For each dependent variable, less than 0.8% of the trials were excluded for these reasons.

I included centered pronounceability, its squared value, previous presentation, and presentation order as predictors in all analyses. Previous presentation was recoded using the effect coding (i.e., as −0.5 and 0.5). I also computed partial autocorrelations for each participant for both reading and decision times. The average partial autocorrelation was significantly higher than zero up to the lag of five trials for both reading and decision times. I thus included the response times on five previous trials as predictors in all response time analyses to account for autocorrelation in the data (Baayen & Milin, 2015). The results for the lagged response times are not reported because they were not relevant to my hypotheses. For the decision times, I also included the answer as a predictor. To reduce unexplained variability in the data and test hypotheses unrelated to the present study (see Casasanto, 2014), I also included dominant hand use and the answer on the dominant hand side as predictors in analyses where they were relevant. The results regarding these variables and regarding presentation order are reported on https://osf.io/3zd62/wiki/home/

I built the final models from an initial model which included all fixed factors and random intercepts for participants and words. I then added random intercepts to this model and checked whether the new random intercepts significantly improved the model. Those that significantly improved the model were then sequentially added to the analysis alongside with their correlations with the other random factors. At each step, I checked whether the inclusion improved the model and stopped when it did not (Bates, Kliegl, Vasishth, & Baayen, 2015). Only the results of the final models are reported (see Tables 1 and 2 for summaries of the results). However, the other models yielded mostly similar results.

# Results

## Reading Time

Supporting H1a, previously presented items were read faster than those that had not been presented before, $t(198.1) = -2.59$, $p = .01$, $b = -0.015$, 95% CI [−0.027, −0.004], $Mdn_{\text{old}}$ = 1,159 ms, $Mdn_{\text{new}}$ = 1,165 ms. Contrary to H1b, easier-to-pronounce words were not read faster, $t(127.2) = 0.14$, $p = .89$, $b = 0.000$, 95% CI [−0.006, 0.007]. Squared pronounceability was also not associated with reading times, $t(118.6) = -0.77$, $p = .44$, $b = -0.002$, 95% CI [−0.007, 0.003]. While previous exposure shortened reading times, pronounceability had no effect.

## Liking

Participants liked more both previously presented, $z = 5.98$, $p < .001$, OR = 1.34, 95% CI [1.22, 1.48], $P_{(\text{like|old})} = 0.518$, $P_{(\text{like|new})} = 0.454$, and easily pronounceable words, $z = 10.29$, $p < .001$, OR = 1.51, 95% CI [1.40, 1.63] (see Figure 2). Both forms of fluency therefore positively influenced liking of words, supporting hypotheses H2a and H2b. A negative effect of pronounceability squared suggested that the effect of pronounceability was somewhat stronger for hard-to-pronounce words, $z = -1.75$, $p = .08$, OR = 0.96, 95% CI [0.91, 1.01]; however, the effect was not significant.

**Table 1.** Final models of logarithmized response times

| | Reading time | Liking decision time | Recognition decision time |
|---|---|---|---|
| | Estimate (CI) | Estimate (CI) | Estimate (CI) |
| Fixed parts | | | |
| Intercept | 0.136 (0.091 to 0.181)*** | 0.635 (0.589 to 0.681)*** | 0.513 (0.470 to 0.555)*** |
| Previous presentation | −0.015 (−0.027 to −0.004)* | −0.007 (−0.020 to 0.006) | −0.008 (−0.021 to 0.005) |
| Pronounceability | 0.000 (−0.006 to 0.007) | 0.005 (−0.000 to 0.011) | 0.007 (0.001 to 0.013)* |
| Pronounceability squared | −0.002 (−0.007 to 0.003) | −0.006 (−0.010 to −0.002)** | −0.001 (−0.005 to 0.003) |
| Answer ("like," "seen") | | −0.005 (−0.018 to 0.009) | −0.094 (−0.110 to −0.078)*** |
| Random parts | | | |
| $ICC_{id}$ | 0.510 | 0.393 | 0.236 |
| $ICC_{word}$ | 0.006 | 0.005 | 0.002 |
| Observations | 14,913 | 7,519 | 7,375 |

*Notes*. Lagged response times, presentation order, dominant hand use, answer on the dominant hand side, and random slopes are not included in the table. ICC = intraclass correlation coefficient. *$p$ < .05; **$p$ < .01; ***$p$ < .001.

**Table 2.** Final models of liking and recognition.

| | Liking | Recognition |
|---|---|---|
| | Estimate (CI) | Estimate (CI) |
| Fixed parts | | |
| Intercept | 1.013 (0.888 – 1.155) | 0.792 (0.686 – 0.913)** |
| Previous presentation | 1.343 (1.219 – 1.479)*** | 2.376 (2.156 – 2.619)*** |
| Pronounceability | 1.511 (1.397 – 1.635)*** | 1.046 (0.970 – 1.128) |
| Pronounceability squared | 0.955 (0.907 – 1.006) | 0.943 (0.890 – 0.999)* |
| Random parts | | |
| $ICC_{id}$ | 0.068 | 0.057 |
| $ICC_{word}$ | 0.036 | 0.052 |
| Observations | 8,016 | 7,906 |

*Notes*. Presentation order, answer on the dominant hand side, and random slopes are not included in the table. ICC = intraclass correlation coefficient. *$p$ < .05; **$p$ < .01; ***$p$ < .001.

## Recognition

Participants were more likely to say that they had seen words which had been previously presented, $z$ = 17.45, $p$ < .001, OR = 2.38, 95% CI [2.16, 2.62], $P_{(\text{seen}|\text{old})}$ = 0.524, $P_{(\text{seen}|\text{new})}$ = 0.335, showing the ability to correctly recognize the previously presented words corresponding to the 59.4% overall correct response rate. Contrary to H3, pronounceability did not influence recognition, $z$ = 1.16, $p$ = .24, OR = 1.05, 95% CI [0.97, 1.13], but squared pronounceability did, $z$ = −1.98, $p$ = .05, OR = 0.94, 95% CI [0.89, 1.00]. The effect suggests an inverted-U shaped relationship between pronounceability and probability of the "seen" answer, which is depicted in Figure 3.

## Liking Decision Time

Previous presentation did not have a significant effect on liking decision times, $t$(196.4) = −1.01, $p$ = .31, $b$ = −0.007, 95% CI [−0.020, 0.006]. Decision times did not differ between "like" and "dislike" answers, $t$(205.9) = −0.64, $p$ = .52, $b$ = −0.005, 95% CI [−0.018, 0.009]. Easier pronounceability was associated with somewhat slower decision times, but the effect was not significant, $t$(124.3) = 1.81, $p$ = .07, $b$ = 0.005, 95% CI [−0.000, 0.011]. Most importantly, supporting H4, I found an inverted-U shaped effect of pronounceability on liking decision times as indicated by the negative squared pronounceability effect, $t$(112.3) = −2.72, $p$ = .008, $b$ = −0.006, 95% CI [−0.010, −0.002] (Figure 4). The model suggested that the slowest decision times were for pronounceability of 4.34 (i.e., close to the midpoint of the scale).

## Recognition Decision Time

Previous presentation did not influence recognition decision times, $t$(6,863.0) = −1.14, $p$ = .26, $b$ = −0.008, 95% CI [−0.021, 0.005]. The responses were faster when participants answered that they had previously seen the word,

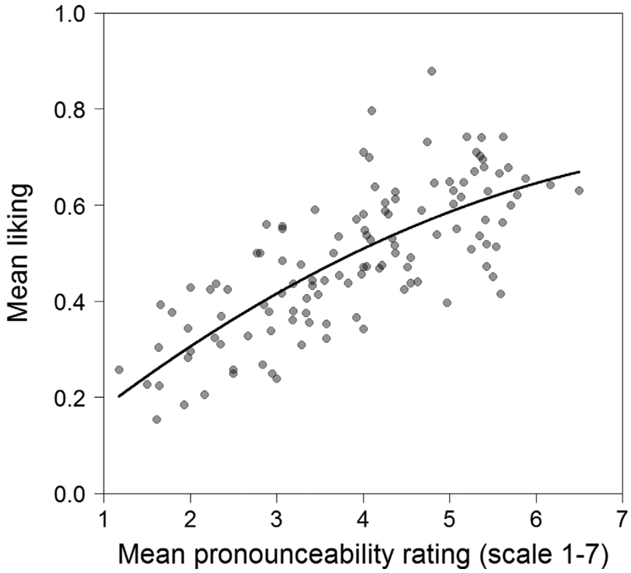


**Figure 2.** The effect of pronounceability on liking. The figure depicts the association between pronounceability and liking at the item level. The regression curve was computed using polynomial regression without any other predictors and with the proportion of "like" answers as a dependent variable.

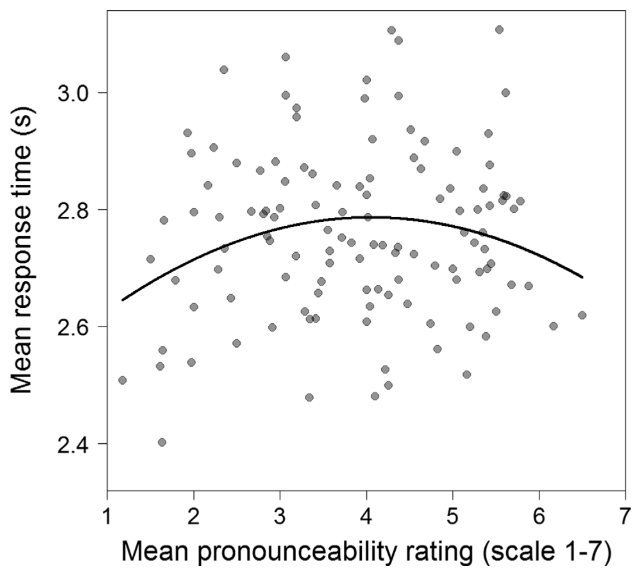


**Figure 4.** The effect of pronounceability on liking decision time. The figure depicts the association between pronounceability and liking decision times at the item level. The regression curve was computed using polynomial regression without any other predictors and with non-transformed decision times as the dependent variable.

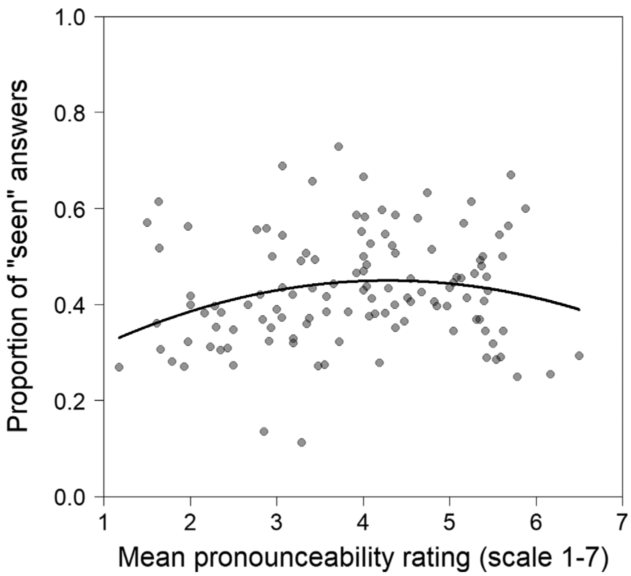


**Figure 3.** The effect of pronounceability on recognition. The figure depicts the association between pronounceability and recognition at the item level. The regression curve was computed using polynomial regression without any other predictors and with the proportion of "seen" answers as the dependent variable.

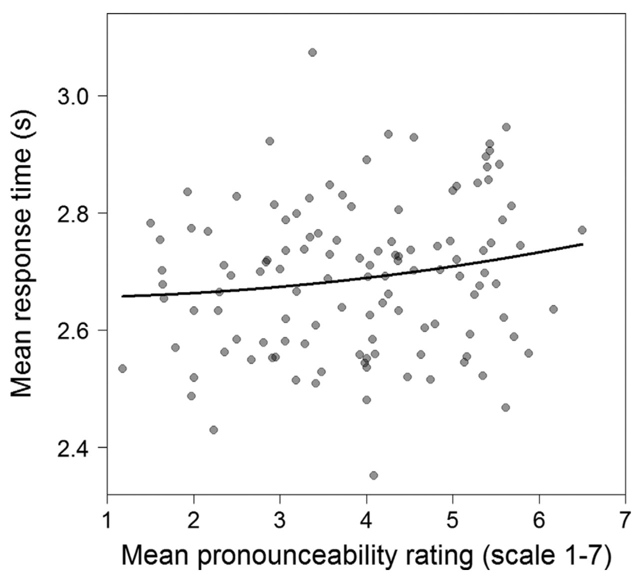


**Figure 5.** The effect of pronounceability on recognition decision time. The figure depicts the association between pronounceability and recognition decision times at the item level. The regression curve was computed using polynomial regression without any other predictors and with non-transformed decision times as the dependent variable.

$t(214.6) = -11.54$, $p < .001$, $b = -0.094$, 95% CI [−0.110, −0.078], $Mdn_{\text{seen}}$ = 2,251 ms, $Mdn_{\text{not seen}}$ = 2,520 ms. Finally, easier pronounceability led to slower decision times, $t(121.6) = 2.37$, $p = .02$, $b = 0.007$, 95% CI [0.001, 0.013], but, contrary to H5, squared pronounceability had no effect, $t(121.5) = -0.41$, $p = .69$, $b = -0.001$, 95% CI [−0.005, 0.003] (Figure 5). The linear effect of pronounceability suggests a possible speed-accuracy tradeoff because participants were more accurate (see supplementary results on https://osf.io/3zd62/wiki/home/), but slower when deciding about easier-to-pronounce words.

## Discussion

The procedure used in the present study allowed me to separate reading and decision times, which are usually confounded in studies of processing fluency. I expected that more difficult pronounceability would lead to slower reading times, but that pronounceability may also serve as a strong cue when making decisions about hard-to-pronounce words, resulting in faster decision times for hard-to-pronounce words than for more easily pronounceable words. Pronounceability positively influenced liking of words. While I did not find the effect of pronounceability on reading times, the results showed the predicted inverted-U shaped effect of pronounceability on liking decision times. Easy-to-pronounce words were easily judged as liked and hard-to-pronounce words as disliked. The difference in the effect of pronounceability on reading and decision times shows that it is important to consider in which part of the judgmental process fluency plays a role. It is also not possible to simply equate fluency with shorter response times unless the response times relate only to a single cognitive process.

Similarly as in previous research (for a review, see Winkielman, Schwarz, Fazendeiro, & Reber, 2003), I found the effect of fluency on liking. Moreover, the effect was present for both types of fluency: As in previous studies, I found the effect of previous presentation on liking, also known as the mere-exposure effect (Zajonc, 1968), and the effect of pronounceability on liking (Laham et al., 2012). The experiment thus replicated the previously found effects using pseudowords as stimuli. A recent study suggested that fluency does not generally lead to positive evaluation, but merely amplifies emotions associated with given stimuli (Albrecht & Carbon, 2014). The present study used neutral pseudowords without any meaning and participants were given both "like" and "dislike" options. Yet, I still found a positive effect of fluency on liking. This suggests that apart from the amplification of affect, fluency also has some general positive effect on liking.

Given the effect of pronounceability on liking, the explanation of the lack of the effect of pronounceability on reading times is not straightforward. One possibility is that pronounceability is related just to one process comprising reading and that fluency of the other processes is not associated with pronounceability. Also, participants in the present experiment did not read out loud the words; therefore, reading speed might not have been so strongly related to pronounceability as it would have been if participants had to actually pronounce the words. Unlike pronounceability, previous presentation influenced reading times; however, the effect was just 6 ms with the median reading time 1,162 ms. It is therefore also possible that the reading time measure was too noisy to reveal other than the strongest effects. Participants could have also responded after seeing the word rather than after reading it. Previous presentation could have then influenced the speed of detection of the word rather than of its reading. Given that it is possible that pronounceability might not have had an effect on reading times because reading times were a poor measure of reading fluency, the lack of the effect does not invalidate other results of the present study. Nevertheless, support for some of the proposed explanations of the lack of the effect would bolster the assumption that pronounceability influenced reading fluency, which was presumably used in subsequent judgment.

Recognition was affected by previous presentation. However, it is not possible to separate the effect of fluency and recollection in the design of the present study. The effect of previous presentation on recognition could have been caused entirely by correct recollection of previously presented stimuli. Even though previous presentation influenced recognition as expected, the relationship between pronounceability and recognition was more complex. I did not find the predicted linear effect of pronounceability on recognition, which would suggest misattribution of fluency to previous presentation of words. However, I found an inverted-U shaped relationship of pronounceability and recognition. That is, easy- and hard-to-pronounce words were more likely to be considered as new in comparison to words moderate in pronounceability. As a speculation, it is possible that participants used a metamemory strategy and inferred that if they could not easily recollect these salient words, they had not seen them. The threshold for reporting recollection would be thus stricter for these words which would result in the inverted-U shaped effect.

Most importantly, the inverted-U shaped relationship of pronounceability and liking decision times supported the prediction that disfluency may be used as a strong cue for disliking and thus lead to faster decisions. It is noteworthy that given the lack of the effect of pronounceability on reading times, the total duration of reading and deciding was lower for disfluent words than for words moderate in fluency. This shows that response times cannot be simply equated with fluency if they do not pertain just to a single cognitive process. While the result has important ramifications for future fluency research, it is not clear how it affects conclusions of previous studies using response times as a measure of fluency. Under certain conditions, the relationship of fluency and response times will be monotonically decreasing as has been often assumed. This might happen, for example, when people use predominantly one of the available answers. Similarly, when participants have only one possible answer available, the relationship can be monotonic. It is also possible that in circumstances where fluency does not vary between stimuli continuously, but has only a limited number of discrete levels, a non-monotonic relationship might be obscured. An example may be when only fluent and disfluent stimuli are used and stimuli moderate in fluency are omitted. The effect of disfluency on the decision time might be also sometimes weaker than an opposite effect on the time of obtaining information, which would result in longer judgment time for disfluent stimuli. Nevertheless, the studies that used response times as a measure of processing fluency without separating the constituting processes may not provide the evidence for studied phenomena they aimed to provide, even if this does not mean that their results are necessarily wrong.

While I did not expect that pronounceability will have the inverted-U shaped effect on decision times only for liking and not for recognition, the result is consistent with the lack of a linear effect of pronounceability on recognition. The association of extreme levels of pronounceability with shorter decision times requires that participants use pronounceability as a cue in judgment. Since recognition was not significantly influenced by pronounceability, the lack of the inverted-U shaped effect for recognition decision times is not surprising.

An important caveat to the present study is that the reported effects of pronounceability of words can be interpreted as effects of fluency only insofar as pronounceability influenced felt fluency, and this feeling of fluency as well as its effects were similar between participants (see Monin & Oppenheimer, 2005; Nickerson, 1995, for a discussion of the limitation). Given a strong correlation[6] of pronounceability ratings between participants and usually observed nonsignificant improvement of a model by adding random slopes for pronounceability, at least some of the concern is alleviated. However, to better estimate the effect of fluency on liking, recognition, and response times, future studies may ask directly about reading fluency instead of pronounceability and have participants rate the same words in terms of liking or recognition and fluency. Despite the described limitations, the study shows that different manipulations of fluency may have different effects on reading and decision speeds, clearly demonstrating that the two processes need to be treated as separate in studies of processing fluency.

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[6] The median correlation of participants' ratings of pronounceability with the average rating was .72 [ranging: .13–.92].

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