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The Dark Side of Fluency: Fluent Names Increase Drug Dosing

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Prior research has demonstrated that high processing fluency influences a wide range of evaluations and behaviors in a positive way. But can high processing fluency also lead to potentially hazardous medical behavior? In 2 controlled experiments, we demonstrate that increasing the fluency of pharmaceutical drug names increases drug dosage. Experiment 1 shows that drugs with fluent names are perceived as safer than those with disfluent names and this effect increases drug dosage for both synthetically produced and herbal drugs. Experiment 2 demonstrates that people chose a higher dosage for themselves and for a child if the drug bears a fluent (vs. disfluent) name. Using linear regression based mediation analysis, we investigated the underlying mechanisms for the effect of fluency on risk perception in more detail. Contrary to prior research, we find that affect, but not familiarity, mediates the fluency-risk link. Our findings suggest that a drug name's fluency is a powerful driver of dosing behavior.

Keywords: fluency, affect, familiarity, risk, drug poisoning

From 2000 to 2014, the death rate due to pharmaceutical drug poisoning more than doubled across the United States (Jones, Mack, & Paulozzi, 2013; Rudd, Aleshire, Zibbell, & Gladden, 2016). Although drug poisoning can be either accidental or intentional, current estimates suggest the majority of incidents occur unintentionally (Jones et al., 2013; Rudd et al., 2016). Various reasons for misdosing drugs have been identified in the literature, such as low numeracy skills (Peters, Hart, & Fraenkel, 2011), limited health literacy (Rothman, Yin, Mulvaney, Homer, & Lannon, 2009; Yin et al., 2008), or the use of ambiguous dosage delivery devices such as spoons (van Ittersum & Wansink, 2016; Wansink & van Ittersum, 2010).

However, an underestimated factor that might contribute to biases in drug dosing could be the pharmaceutical drug name. Some drug names are easy-to-pronounce (e.g., Crestor, Panadol, Humira), other names are rather difficult-to-pronounce (e.g., Umckaloabo, Amoxicillin, Idarucizumab). Thus, drug names differ in their processing fluency, that is, the subjective experience of ease with which people process information (Alter & Oppenheimer, 2009b; Reber, Schwarz, & Winkielman, 2004; Schwarz, 2004; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). In the current experiments, we investigated whether a drug name's fluency systematically biases dosing behavior.

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Effects of Fluency on Evaluation and Behavior

Human judgments are not only influenced by the content of one's thoughts but also by the metacognitive experience of processing those thoughts (Alter & Oppenheimer, 2009b; Schwarz, 2004, 2010, 2015). One form of such metacognitive experiences is the fluency with which new information can be processed. A large body of research has demonstrated that people tend to judge stimuli that are fluent, or easy to process, more positively on a wide range of evaluative dimensions. For example, people perceive fluent stimuli as more likable (Laham, Koval, & Alter, 2012), true (Reber & Schwarz, 1999; Unkelbach, 2007), intelligent (Oppenheimer, 2006), beautiful (Graf & Landwehr, 2015), and tasty (Gmuer, Siegrist, & Dohle, 2015). In addition, fluency tends to have a predominantly positive influence on real-life behavior and high-involvement decisions: High fluency leads to more favorable stock performance (Alter & Oppenheimer, 2006), increases car sales (Landwehr, Labroo, & Herrmann, 2011), and influences recruitment and participation for health interventions (Manley, Lavender, & Smith, 2015).

Recent research, however, suggests that under certain conditions, disfluency may lead to superior outcomes and decisions (Alter, 2013; Alter & Oppenheimer, 2009a; Diemand-Yauman, Oppenheimer, & Vaughan, 2011). Although some of the beneficial effects of disfluency have been the subject of scientific debate (Eitel, Kuhl, Scheiter, & Gerjets, 2014; Rummer, Schweppe, & Schwede, 2016), there is growing evidence that disfluency may sensitize people to risks (Alter & Oppenheimer, 2009a; Dohle & Siegrist, 2014; Song & Schwarz, 2009). For example, in a study by Song and Schwarz (2009), participants evaluated food additives with disfluent, difficult-to-pronounce names (e.g., Hnegripitrom) as more hazardous than food additives with fluent, easy-to-pronounce names (e.g., Magnalroxate). In addition, the food additives with disfluent names were perceived as more novel, and novelty mediated the effect of fluency on hazardousness. Building on the research by Song and Schwarz (2009), a recent consumer

study demonstrated that fluency also plays an important role in the evaluation of pharmaceutical drugs (Dohle & Siegrist, 2014). In this study, participants were asked to make judgments of fictitious drugs with fluent, easy-to-pronounce names or disfluent, difficult-to-pronounce names. Following the presentation of the drug name, participants judged how hazardous they perceived the drug to be, and how willing they would be to buy the drug. Willingness to buy was greater for drugs with fluent names compared to disfluent names, and perceived hazardousness mediated this effect. However, these studies do not answer the question of whether high-risk perception due to disfluency also translates into real-life medical behavior. It is likely that the fluency of drug names may unknowingly bias dosing behavior, because people assume that drugs with fluent names are safe, suggesting a "dark side" of fluency.

Affect and Familiarity as Possible Mediators of the Fluency-Risk Relationship

Despite the strong evidence demonstrating the effect of fluency on risk perception, the underlying mechanism of the fluency-risk relationship is not fully understood. Some authors have argued that high fluency is experienced as pleasant and elicits immediate low-level affective responses ("hedonic marking hypothesis"; Winkielman & Cacioppo, 2001; Winkielman et al., 2003). According to this perspective, high fluency elicits positive affect because it provides feedback about ongoing cognitive operations (Reber et al., 2004; Winkielman et al., 2003). Specifically, high fluency indicates that current cognitive processing is efficient and triggers positive affect due to the reinforcing value of maintaining the current, successful cognitive strategy and the ability to free resources for other tasks (Winkielman, Schwarz, & Nowak, 2002). The hedonic marking hypothesis therefore suggests that affective reactions are immediate and automatic consequences of encountering fluent stimuli in the environment (Graf & Landwehr, 2015), and that affective reactions, either captured via psychophysiological indicators (Winkielman & Cacioppo, 2001) or by self-reports (Reber, Winkielman, & Schwarz, 1998), serve a crucial mediating role between fluency and risk perceptions.

Other researchers have argued that fluency influences risk perception primarily through its effect on perceived familiarity (Schwarz, Song, & Xu, 2009; Song & Schwarz, 2009). This assumption builds on research indicating that ease of processing increases feelings of familiarity (Jacoby & Whitehouse, 1989; Whittlesea, Jacoby, & Girard, 1990). For example, in a study by Whittlesea and colleagues (1990) participants saw a short and rapidly presented list of words. Afterward, participants were shown test words—which differed in visual clarity—and asked whether the words had appeared on the previous list or not. When test words were visually clearer (i.e., easy rather than difficult to process), participants were more likely to misidentify novel words as having appeared previously. Because fluent stimuli are seen as more familiar than disfluent stimuli, they should also be perceived as less threatening and less risky—people may feel that if a stimulus is familiar, it presumably has not hurt anyone in the past (Schwarz et al., 2009). Empirical evidence for the fluency-familiarity-risk link has been demonstrated in the study by Song and Schwarz (2009), in which the effect of fluency of different food additives on risk ratings was mediated by the perceived novelty of the stimuli. This result is consistent with the argument that perceived familiarity is the key mediator in intuitive judgments of risk; however, it is possible that judgments of risk may be further influenced by peoples' positive affective response to fluently processed stimuli (Schwarz, 2010, 2015).

A more rigorous test of mediation would take all possible mediators of the fluency-risk relationship into account. To the best of our knowledge, however, no prior research on fluency and risk perception has assessed the mediating effects of affect and familiarity simultaneously, and we aim to close this research gap. Thus, the purpose of this research is twofold. First, we want to demonstrate that the processing fluency of pharmaceutical drug names not only influences judgments of risks, but also affects dosing behavior (Experiments 1 and 2). We hypothesize that fluently processed drug names lead to higher dosages compared to disfluent names, because they are perceived as less risky. Second, we want to explore the fluency-risk link in more detail by testing two potential mediators (affect and familiarity) in parallel (Experiment 2). The parallel mediation allows us to assess the relative contributions of affect and familiarity in mediating the well-established link between fluency and risk perception.

Experiment 1

In Experiment 1, we asked participants to pour liquid drugs in the lab. The drug names differed in terms of processing fluency: some were easy-to-pronounce, others were difficult-to-pronounce. We hypothesized that drugs with easy-to-pronounce names would be perceived as less hazardous (i.e., would reduce risk perception), and that decreases in perceived hazardousness would increase drug dosing (see Figure 1). The type of drug was manipulated as well: each participant was told that the drugs were either synthetically produced or that they were herbal drugs which only contained natural ingredients. Prior research has shown that most laypeople consider substances of natural origin less dangerous than synthetically produced substances, following the notion that 'natural means safe' (Kraus, Malmfors, & Slovic, 1992). Thus, we expected a main effect of drug type on drug dosing, because people's tendency to judge natural products as safe could result in an increased dosage for herbal drugs. Moreover, it is possible that the effect of drug name on hazardousness could be attenuated for herbal drugs compared to synthetic drugs, suggesting moderated mediation (see Figure 2).

Method

Participants were 70 volunteers (60 females, 10 males) who were recruited from a large European university. Mean age of the

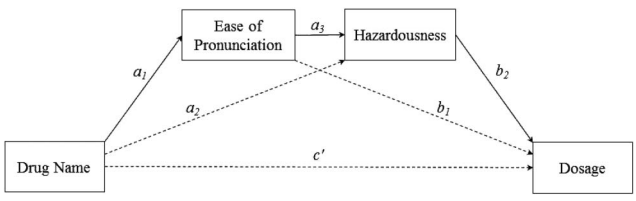

Figure 1. Serial mediation model (Experiment 1). Solid lines indicate statistically significant paths, and dashed lines indicate statistically nonsignificant paths ($\alpha = .05$).

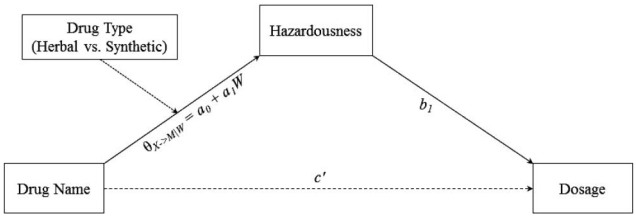

Figure 2. Moderated Mediation (Experiment 1). Solid lines indicate statistically significant paths, and dashed lines indicate statistically nonsignificant paths ($\alpha = .05$).

sample was 24.19 ($SD = 6.36$). The study employed a 2 × 2 mixed design, with drug name (fluent vs. disfluent) as within-subjects factor and type of drug (synthetic vs. herbal) as between-subjects factor. Post-hoc power analysis, based on the effect size obtained in the current study, showed that the final sample size ensured sufficient power (i.e., 0.99) for detecting a main effect for drug name ($\alpha = .05$).

Drug names were chosen based on a pretest (see also Dohle & Siegrist, 2014), where German-speaking participants rated the ease with which the names of 16 ostensible pharmaceutical drugs could be pronounced on a scale extending from 'very easy' (1) to 'very difficult' (7). The 16 pretest words, composed of 12 letters, were taken from Song and Schwarz (2009). The three easiest (i.e., Fastinorbine, Tonalibamium, Calotropisin) and the three most difficult words (i.e., Cytrigmcmium, Nxungzictrop, Ribozoxtlitp) were used for the present experiment; the difference in ease of pronunciation was significant, t (19) = 20.32, $p < .001$.

All participants were tested individually in the same experimental lab, and the materials were presented in German. Written informed consent was obtained from all participants. Upon arrival, participants were greeted by the experimenter and were told that they were participating in a study on pharmaceutical drugs. They were asked to imagine that they were suffering from gastric flu, and that six different liquid drugs could be considered to treat the illness. Half of the participants were told that all drugs were synthetic drugs, the other half were informed that all drugs were herbal drugs. The recommended daily dose for each drug was 10–20 ml (mL).

Next, participants were consecutively presented with six medicine bottles, each of which was labeled with a fluent, easy-to-pronounce drug name or a disfluent, difficult-to-pronounce name. The six drugs were presented in two different orders, and participants were randomly assigned to one of the orders (Order 1: Calotropisin, Cytrigmcmium, Fastinorbine, Nxungzictrop, Ribozoxtlitp, Tonalibamium; Order 2: Tonalibamium, Ribozoxtlitp, Nxungzictrop, Fastinorbine, Cytrigmcmium, Calotropisin). Presentation order did not impact any of the outcomes of interest and was not included in any of the analyses reported. All bottles contained 200 mL of liquid drug (which was, in fact, colored water). For each drug, participants were asked to use a measuring cup (with capacity in mL) and one of six transparent cups to pour the amount of liquid drug that they would take during one entire week at the maximum. Weekly dosage was chosen to maximize experimental variance. After participants poured the liquid drug into the transparent cup, the experimenter took the cup away and presented the next bottle. This procedure was repeated until participants had poured all six drugs. Finally, participants received a short questionnaire on which all drug names were presented again. As manipulation checks, participants indicated for each drug how easily the name could be pronounced (1 = *very easy*, 9 = *very difficult*) and whether the drugs were synthetic or herbal. In addition, participants made judgments about the drugs' hazardousness (1 = *not hazardous*, 9 = *very hazardous*) and indicated whether they believed that an overdose would be dangerous (1 = *not dangerous*, 9 = *very dangerous*). After participants were debriefed and left the room, research assistants measured and recorded the volume of liquid drug (in mL) in each of the six cups.

Results

Manipulation check. Analysis of the manipulation checks showed that disfluent names were more difficult to pronounce, t (69) = 30.46, $p < .001$, $d_{RM} = 3.64$ [2.96, 4.32], $r = .13$.[1] In addition, 85.70% of the participants correctly remembered that the drugs were either synthetic or herbal.[2]

ANOVA. A 2 (drug name: fluent vs. disfluent) × 2 (type of drug: synthetic vs. herbal) mixed ANOVA revealed a significant main effect for drug name on dosage, F (1, 68) = 48.37, $p < .001$, $\eta_p^2 = .42$. As Table 1 indicates, drug dosage was higher for drugs with fluent names ($M = 89.28$, $SD = 30.61$) than to drugs with disfluent names ($M = 78.23$, $SD = 32.23$). The main effect for type of drug was not significant, F (1, 68) = 1.77, $p = .188$, $\eta_p^2 = .03$. In addition, no significant interaction effect was found, $p > .250$.

Mediation. Next, MEMORE (Montoya & Hayes, 2017) for SPSS was used to test the indirect effect of drug name on dosing through ease of pronunciation and perceived hazardousness in serial (see Figure 1). Hazardousness was computed as an average of the measure of hazardousness and belief in dangerousness of overdose ($\alpha_{\text{fluent}} = 0.73$, $\alpha_{\text{disfluent}} = 0.70$). Ninety-five percent confidence intervals were generated from 10,000 bootstrap samples and are reported in brackets for each result below. Additionally, we report partially standardized indirect effects as an effect size (*p*s, see, e.g., Hayes, 2013). These are the indirect effects divided by the standard deviation of the difference in dosing.

We hypothesized that the serial indirect effect of drug name on drug dosage through ease of pronunciation and perceived hazardousness would be significant. We did not predict an indirect effect of drug name on dosage solely through ease of pronunciation. Because we expected that the influence of drug on hazardousness would operate on drug dosage *only* through its effect on ease of pronunciation, we did not expect there to be an indirect effect of drug name on dosage solely through hazardousness. If this indirect effect is significant, this would indicate that our manipulation did

[1] All effect sizes for repeated-measures pairwise comparisons are denoted d_{RM} denoting the effect size outlined by Gibbons, Hecker, and David (1993) which is the ratio of the average difference between the two conditions and the standard deviation of the difference scores. Additionally, we report the correlation among the two repeated measures *r*. Morris and DeShon (2002) describe how to use d_{RM} and *r* to convert to the same metric as a between subjects effect size. 95% confidence intervals are estimated using variance estimates from Morris and DeShon (2002) and assuming *t*-distributions with *n*-1 degrees of freedom.

[2] Excluding participants who did not pass the manipulation check on type of drug does not change the conclusions.

Table 1
Mean Weekly Dosage for Drugs With Fluent and Disfluent Names (Experiments 1 and 2)

	Experiment 1		Experiment 2	
	Type of Drug		Patient	
	Herbal	Synthetic	Self	Child
Fluent Names	94.10 (29.09)	84.46 (31.74)	7.39 (7.96)	5.68 (6.64)
Disfluent Names	83.11 (32.95)	73.35 (31.19)	6.72 (8.06)	4.99 (5.99)

Note. Standard deviations are given in parentheses. In Experiment 1, participants poured liquid drugs (in mL); in Experiment 2, participants indicated number of tablets. Fluency of name was manipulated within-subjects, whereas type of drug and patient were manipulated between-subjects.

more than manipulate fluency. Finally, we did not predict a significant direct effect between drug name and dosage, as this would indicate some effect of name on dosage not through fluency.

The results showed that the total effect of drug name on dosing was significant, ($c = -11.05$ [−14.19, −7.90], t (69) = −7.01, $p < .001$, $d_{RM} = 0.84$ [0.55, 1.12], $r = .91$), meaning that disfluent names, on average, lead to lower drug dosage; this result mirrors the ANOVA results presented above. Moreover, fluent names were rated easier to pronounce ($a_1 = 5.11$ [4.78, 5.45], t (69) = 30.46, $p < .001$), as noted above in the manipulation check. In addition, ease of pronunciation was significantly related to hazardousness ratings ($a_3 = 0.26$ [0.001, 0.52], t (67) = 2.00, $p = .049$). Controlling for differences in ease of pronunciation, there were no significant differences in perceived hazardousness of fluent and disfluent drugs ($a_2 = 0.76$ [−0.62, 2.15], t (67) = 1.10, $p > .250$). Ease of pronunciation was not significantly related to dosage while controlling for hazardousness ($b_1 = 0.22$ [−1.98, 2.41], $t(65) = 0.20$, $p > .250$), but perceived hazardousness was negatively related to drug dosage, while controlling for ease of pronunciation ($b_2 = -3.52$ [−5.51, −1.53], t (65) = −3.54, $p = .001$).

As hypothesized, there was a significant serial indirect effect of drug name on dosage through ease of pronunciation and hazardousness ($a_1a_3b_2 = -4.72$ [−10.30, −.45], $ps = -0.36$). This indicates that weekly dosage of disfluent drugs is expected to be 4.72 mL lower than fluent drugs through the effect of drug name on ease of pronunciation which affects perceived hazardousness which then influences drug dosage. However, there was no significant indirect effect through hazardousness only ($a_2b_2 = -2.68$ [−7.51, 1.22], $ps = -0.20$). This means that there was not a significant influence of drug name on dosage through hazardousness which did not operate through ease of pronunciation, supporting the hypothesis that fluency is the primary mechanism through which the different drug names operate on dosage. We also found no significant indirect effect through ease of pronunciation only ($a_1b_1 = 1.10$ [−9.33, 11.96], $ps = -0.08$). The direct effect of drug name on dosage, while controlling for ease of pronunciation and hazardousness, was not significant ($c' = -4.74$ [−16.12, 6.64], t (65) = −0.83, $p > .250$).

Moderated Mediation. Next, bootstrapping procedures were used to test if the indirect effect of drug name on dosage through perceived hazardousness was moderated by type of drug (synthetic vs. herbal). The methods for including moderation in the model were based on the methods outlined by Judd, McClelland, and Smith (1996), and the methods for deriving the index of moderated mediation were based on Hayes (2015). This analysis was implemented using a macro written in SPSS by the second author based on MEMORE (Montoya & Hayes, 2017). Previous research suggests natural drugs may be seen as safer (Kraus et al., 1992), thus we allowed the path from drug name to hazardousness to be moderated by drug type, but no other paths were moderated (see Figure 2). The conditional effect of drug name on hazardousness is denoted by $\theta_{X\rightarrow M}(W) = a_0 + a_1W$. Drug type was a dichotomous indicator variable, where 0 indicated the herbal condition, and 1 indicated the synthetic condition. This means that in the herbal condition, the effect of drug name on hazardousness is estimated as a_0, and in the synthetic condition the effect of drug name on hazardousness is estimated as $a_0 + a_1$. We did not include ease of pronunciation as a mediator to simplify the model, but based on the findings of the mediation analysis, we were confident that the influence of drug name moves primarily through ease of pronunciation. Ninety-five percent confidence intervals were generated from 10,000 bootstrap samples and are reported in brackets for each result below. The total effect in this model is the same as those in the mediation analysis (see above). We hypothesized that drug type would moderate the indirect effect, such that the indirect effect of drug name on dosage through hazardousness would be attenuated for herbal drugs compared to synthetic drugs.

The results showed that participants in the herbal drug condition rated the disfluent drugs 1.97 units more hazardous than the fluent drugs ($a_0 = 1.97$ [1.45, 2.50], $t(68) = 7.52$, $p < .001$, $d_{RM} = 1.28$ [0.95, 1.60], $r = .02$). Participants in the synthetic condition, compared to those in the herbal condition, did not show a larger or smaller difference in hazardousness ratings of disfluent compared to fluent drugs ($a_1 = 0.27$ [−0.47, 1.01], t (68) = 0.719, $p > .250$). Higher perceived hazardousness was related to reduced drug dosage ($b_1 = -3.44$ [−5.35, −1.53], $p = .001$).

There was a significant indirect effect of drug name on dosage through hazardousness in both the herbal condition ($a_0b_1 = -6.78$ [−11.18, −3.40], $ps = -0.51$) and the synthetic drug condition ($[a_0+a_1]b_1 = -7.70$ [−11.98, −3.91], $ps = -0.58$). This means that disfluent drugs are expected to be dosed 6.78 mL less and 7.70 mL less than fluent drugs in the herbal and synthetic conditions, respectively, through the indirect effect of drug names on dosage through hazardousness. The index of moderated mediation (Hayes, 2015) was not significant ($a_1b_1 = -.92$ [−3.89, 1.58]) indicating that the indirect effect does not significantly differ between drug type conditions.[3] Controlling for hazardousness, there was no significant effect of drug name on dosage ($c' = -3.81$ [−8.77, 1.16], t (67) = −1.53, $p = .131$).

Discussion

The first study provides clear support for the hypothesis that fluent drug names increase drug dosage relative to disfluent drug

[3] Because the test of moderated mediation was not statistically significant, we believe the indirect effect reported in the Mediation section to be the best estimate of the indirect effect. Separate indirect effects by condition are reported for completeness, use in future replication, and meta-analysis, but should not be interpreted as meaningfully different from one another.

names. The mediation analysis suggests that drug name disfluency indirectly reduces dosing through its effect on perceived hazardousness, which in turn lowers dosing, and does not support the conclusion that drug name disfluency operate independently of this mechanism. Moreover, there was no main effect of type of drug, and we found no indication that the mediation was moderated by drug type. Although these results were unexpected, the finding supports the robustness of the indirect effect across contexts.

Experiment 2

Experiment 2 was designed to test the underlying process of the fluency-risk association in more detail. The inclusion of two parallel mediators (affect and familiarity) between fluency and risk perception allowed us to pit the two competing theories of mechanism against each other (see Figure 3).

We also manipulated whether the drug was self-administered or administered to a child. We expected that participants would take into account that children would need lower dosages than adults, resulting in a main effect for dosage. Moreover, prior research (Asch et al., 1994; Lupton, 2011; Salmon et al., 2005) suggests that perceptions of risk are highly relevant for medical decisions on behalf of a child. Therefore, we assumed that risk ratings would be of more consequence for dosing decisions when the drug is administered to a child, suggesting a moderated mediation (see Figure 4).

Method

Participants (N = 332; 50% females) were recruited via a professional online panel provider that assured sampling quality by carefully selecting panelists. The following criteria were applied: Participants must be 18–69 years of age, and the sample must have an equal distribution of men and women. Each participant provided informed consent and was paid €0.50. Participants' mean age was M = 43.66 (SD = 13.80). The study employed a 2 × 2 mixed design, with drug name (fluent vs. disfluent) as within-subjects factor and patient (self vs. child) as between-subjects factor.

The study was conducted online, and the materials were presented in German. Half of the participants were asked to imagine that they were suffering from the flu, whereas the other half was asked to imagine that an 8-year-old child had the flu. Next, participants were confronted with pictures of six different drug boxes, each of which was imprinted with an easy-to-pronounce or a difficult-to-pronounce name. The same names as in Experiment 1 were used, and the drug boxes were presented in two different orders (Order 1: Fastinorbine, Cytrigmcmium, Nxungzictrop, Tonalibamium, Ribozoxtlitp, Calotropisin; Order 2: Calotropisin, Ribozoxtlitp, Tonalibamium, Nxungzictrop, Cytrigmcmium, Fastinorbine). Presentation order did not impact any of the outcomes of interest; thus, it was not included in any of the analyses reported. For each drug, participants were asked to indicate the maximal number of tablets that they (or the child) should take. No information on recommended dose was given. After the dosing task, participants answered additional questions. They made judgments about the pleasantness (1 = *very unpleasant*, 9 = *very pleasant*) and familiarity (1 = *very unfamiliar*, 9 = *very familiar*) of the drug's name. Participants also indicated whether they believed that an overdose would be dangerous (1 = *not dangerous*, 9 = *very dangerous*) and whether they would expect side effects (1 = *no side effects*, 9 = *strong side effects*). As a manipulation check, participants were asked for each drug how easily the name could be pronounced (1 = *very difficult*, 9 = *very easy*).

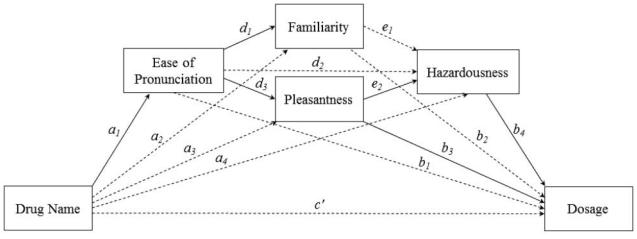

Figure 3. Parallel-serial mediation model (Experiment 2). Solid lines indicate statistically significant paths, and dashed lines indicate statistically nonsignificant paths (α = .05).

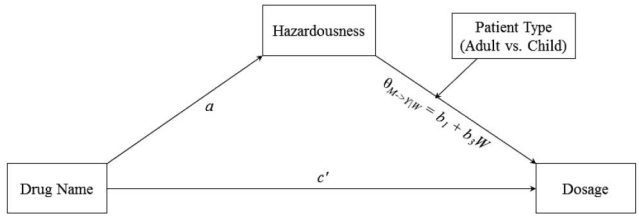

Figure 4. Moderated Mediation (Experiment 2). Solid lines indicate statistically significant paths, and dashed lines indicate statistically nonsignificant paths (α = .05).

Results

Manipulation check. The manipulation check indicated that fluent names were easier to pronounce, t (331) = 21.17, $p < .001$, d_{RM} = 1.16 [1.02, 1.30], r = .37.

ANOVA. The mean weekly dosage for drugs with fluent and disfluent names are shown in Table 1. A 2 (drug name: fluent vs. disfluent) × 2 (patient: self vs. child) mixed ANOVA revealed a significant main effect for drug name, F (1, 330) = 13.44, $p < .001$, η_p^2 = .04. Drug dosage was higher for drugs with fluent names (M = 6.56, SD = 7.39) compared to drugs with disfluent names (M = 5.88, SD = 7.17). The main effect for patient was also significant, F (1, 330) = 4.92, p = .027, η_p^2 = .02. In general, participants chose a lower drug dosage for a child (M = 5.34, SD = 6.06) than for themselves (M = 7.05, SD = 7.86). No significant Drug Name × Patient interaction was found, $p > .250$.

Mediation. Prior to the mediation analysis, dangerousness of overdose and expectation of side effects were averaged to indicate the "hazardousness" of the drug (α_{fluent} = 0.71, $\alpha_{disfluent}$ = 0.69). We tested the indirect effect of drug name on dosing through a serial parallel model where drug name predicts ease of pronunciation which then predicts familiarity and pleasantness which then predict hazardousness, leading to dosage (see Figure 3). This model is very similar to a serial mediation model, however in this model no order is assumed between pleasantness and familiarity. Bootstrapping procedures were used to compute confidence intervals for the indirect effects. This analysis was implemented using

a macro written in SPSS by the second author based on MEMORE (Montoya & Hayes, 2017). Ninety-five percent confidence intervals were generated from 10,000 bootstrap samples and are reported in brackets for each result below.

There are 11 indirect effects in this model. We were particularly interested in two serial indirect effects: (a) the indirect effect of drug name on dosage through ease of pronunciation, familiarity, and hazardousness in serial; and (b) the indirect effect of drug name on dosage through ease of pronunciation, pleasantness, and hazardousness in serial. We expected all indirect effects which do not move through ease of pronunciation to be indistinguishable from zero (e.g., the indirect effect of drug name on dosage through only pleasantness). If any of these indirect effects are significant, this would indicate that there is an effect of drug name on dosage not through fluency.

The results demonstrate that the total effect of drug name on dosing was significant, ($c = -0.68$ [-1.04, -0.32], $p < .001$, $d_{RM} = -0.20$ [-0.31, -0.09], $r = .89$), meaning that disfluent names, on average, lead to lower drug dosage; this result mirrors the ANOVA results presented above. Moreover, disfluent names were perceived as more difficult to pronounce ($a_1 = 2.85$ [3.11, 2.58], $p < .001$). Names which were easier to pronounce were seen as more familiar ($d_1 = 0.12$ [0.07, 0.16], $p < .001$) and more pleasant ($d_3 = 0.20$ [0.16, 0.24], $p < .001$). Controlling for pleasantness and ease of pronunciation, differences in familiarity did not predict differences in hazardousness ($e_1 = 0.01$ [-0.08, 0.10], $p > .250$). However, controlling for familiarity and ease of pronunciation, differences in pleasantness did predict differences in hazardousness ($e_2 = -0.33$ [-0.43, -0.23], $p < .001$). While controlling for all other mediators, pleasantness independently predicted dosage ($b_3 = 0.64$ [0.05, 1.23], $p = .033$), and hazardousness independently predicted dosage ($b_4 = -2.03$ [-2.65, -1.42], $p < .001$). See Table 2 for all path estimates and confidence intervals.

The indirect effect of drug name on dosing via ease of pronunciation, familiarity, and hazardousness in serial was not significant ($a_1d_1e_1b_4 = -0.10$ [-0.32, 0.05], $ps = -0.03$). The indirect effect of drug name on dosing via ease of pronunciation, pleasantness, and hazardousness in serial was statistically significant ($a_1d_3e_2b_4 = -0.16$, [-0.36, -0.01], $ps = -0.05$). This indirect effect means that we expect individuals to dose approximately 0.16 fewer tablets per week when the drug name is disfluent, through the indirect effect of drug name on ease of pronunciation, which then affects pleasantness, which then affects hazardousness, ultimately influencing dosage. The confidence intervals for all other indirect effects included zero, see Table 3 for estimates and bootstrap confidence intervals. The direct effect of fluency on dosing (controlling for all mediators) was not significantly different from zero ($c' = -0.14$ [-0.44, 0.73], $p > .250$).

Moderated mediation. Bootstrapping procedures were used to test if the indirect effect of drug name on dosage through perceived hazardousness was moderated by patient (self vs. child). This analysis was implemented using a macro written in SPSS by the second author based on MEMORE (Montoya & Hayes, 2017). Because dosage may be more influenced by perceptions of hazardousness for children than for adults (Asch et al., 1994; Lupton, 2011; Salmon et al., 2005), we allowed the path from hazardousness to dosage to be moderated by patient type (see Figure 4). No other paths were moderated. The conditional effect of hazardousness on dosage is denoted by $\theta_{M \rightarrow Y|W} = b_1 + b_3W$. Patient type was a dichotomous indicator variable, where 0 indicated the self-administration, and 1 indicated the administration to a child. This means that for those who dosed for themselves, the effect of hazardousness on dosage is estimated as b_1, and for those who dosed the child, the effect of hazardousness on dosage is estimated as $b_1 + b_3$. We did not include ease of pronunciation, pleasantness, or familiarity as mediators to simplify the model, but the mediation findings suggest the influence of drug name moves primarily through ease of pronunciation, which, in turn, influences pleasantness. Ninety-five percent confidence intervals were generated from 10,000 bootstrap samples and are reported in brackets for each result below. The total effect is the same as in the mediation analysis (see above) and so is not reported here.

We hypothesized that there would be an indirect effect of drug name on dosage for both adults and children. We believed it was likely that the indirect effect would be stronger for children, as hazardousness may more strongly predict dosage for children than for adults. However, we believed the indirect effect would still be

Table 2
Estimates and 95% Confidence Intervals for Individual Paths (Experiment 2)

Path	Predictor	Outcome	Path estimate	Standard error	95% CI
a_1	Drug Name	Ease of Pronunciation	2.85	.13	[2.58, 3.11]
a_2	Drug Name	Familiarity	−.04	.08	[−.20, .12]
a_3	Drug Name	Pleasantness	−.05	.02	[−.19, .09]
a_4	Drug Name	Hazardousness	−.01	.05	[−.12, .09]
b_1	Ease of Pronunciation	Dosage	.004	.10	[−.19, .20]
b_2	Familiarity	Dosage	−.15	.26	[−.66, .36]
b_3	Pleasantness	Dosage	.64	.30	[.05, 1.23]
b_4	Hazardousness	Dosage	−2.03	.31	[−2.65, −1.42]
c	Drug Name	Dosage	−.68	.18	[−1.04, −.32]
c'	Drug Name	Dosage	.14	.30	[−.44, .73]
d_1	Ease of Pronunciation	Familiarity	.12	.02	[.07, .16]
d_2	Ease of Pronunciation	Hazardousness	.02	.02	[−.01, .06]
d_3	Ease of Pronunciation	Pleasantness	.20	.02	[.16, .24]
e_1	Familiarity	Hazardousness	.01	.05	[−.08, .10]
e_2	Pleasantness	Hazardousness	−.33	.05	[−.43, −.23]

Table 3
Path Estimates and 95% Bootstrap Confidence Intervals for the Indirect Effects (Experiment 2)

Indirect effect	Mediators	Path estimate	95% CI
a_1b_1	Ease of Pronunciation	−.10	[−.68, .40]
$a_1d_1b_2$	Ease of Pronunciation, Familiarity	−.03	[−.23, .21]
$a_1d_1e_1b_4$	Ease of Pronunciation, Familiarity, Hazardousness	−.10	[−.32, .05]
$a_1d_2b_4$	Ease of Pronunciation, Hazardousness	.02	[−.28, .25]
$a_1d_3e_2b_4$	Ease of Pronunciation, Pleasantness, Hazardousness	−.16	[−.36, −.01]
$a_1d_3b_3$	Ease of Pronunciation, Pleasantness	−.17	[−.47, .12]
a_2b_2	Familiarity	.003	[−.05, .06]
$a_2e_1b_4$	Familiarity, Hazardousness	.01	[−.02, .09]
a_3b_3	Pleasantness	.004	[−.03, .04]
$a_3e_2b_4$	Pleasantness, Hazardousness	.004	[−.02, .03]
a_4b_4	Hazardousness	−.021	[−.25, .18]

present for adults, but perhaps not as strong. Finding evidence of the indirect effect in each condition (self and child) would support the robustness of the indirect effects across contexts.

On average, participants viewed disfluent drugs as 0.12 units more hazardous than fluent drugs ($a = 0.12$ [0.05, 0.18], $t(331) = 3.52$, $p < .001$, $d_{RM} = -0.19$ [−0.30, −0.08], $r = .94$). Higher perceived hazardousness was related to reduced drug dosage for adults ($b_1 = -1.58$ [−2.22, −0.95], $p < .001$), and this effect was −2.96 units stronger for children ($b_3 = -2.96$ [−4.15, −1.77], $p < .001$). As hypothesized, there was a significant indirect effect of drug name on dosage through hazardousness in both the self-administration condition ($ab_1 = -0.18$ [−0.32, −0.06], $ps = -0.05$) and the child-administration condition ($a(b_1+b_3) = -0.52$ [−1.20, −0.02], $ps = -0.15$). This means that based on the indirect effect of drug name on dosage through hazardousness, disfluent drugs are expected to be dosed 0.18 units less for adults and 0.52 units less for children. The index of moderated mediation (Hayes, 2015), however, was not significant ($ab_3 = -.34$, [−1.01, 0.15]) indicating that the indirect effect does not significantly differ between patient types.[4] Controlling for hazardousness, there was a statistically significant direct effect of drug name on dosage ($c' = -0.46$ [−0.91, −0.01], $t(326) = -1.99$, $p = .047$).

Discussion

As in Experiment 1, this study demonstrates that a drug name's fluency has a strong influence on dosing behavior. In addition, the parallel mediation model suggests that fluency increases pleasantness; as a result, ratings of hazardousness are reduced for drugs with fluent names. Moreover, although participants dosed more cautiously and adjust their dosing behavior when they consider a dosage for an 8-year old child, the drug name's fluency effect on dosage was present regardless of whether the drug dosage was for oneself or for a child. In addition, no indication was found that the influence of drug name on dosing through hazardousness was increased when participants chose a dosage for a child (moderated mediation).

General Discussion

The present research demonstrates that drug name fluency systematically biases people's dosing behavior. In two experiments, participants chose a higher dosage for drugs with fluent names compared to drugs with disfluent names. We also provide evidence for the hypothesized mechanism underlying this effect; to date, few attempts have been made to separate the relative contributions of different pathways through which fluency influences risk-related evaluations (Schwarz, 2010, 2015). We found that fluent drug names resulted in more positive affective responses which reduced the perceived risks of drugs. Hence, contrary to prior research (Song & Schwarz, 2009), we did not find evidence that familiarity mediated the fluency-risk link. This result is likely due to the fact that we considered both mediators simultaneously. Thus, our research adds to the evidence that fluency is an inherently positive experience (Winkielman & Cacioppo, 2001; Winkielman et al., 2003), and that positive reactions due to high processing fluency directly influence evaluations and behaviors, including evaluations of risks.

One important difference between Experiment 1 and Experiment 2 merits discussion. A large portion of the sample in Experiment 2 showed no differences on drug dosage (69% in Experiment 2 vs. 2.9% in Experiment 1). This may have occurred due to an anchoring effect which is a byproduct of using a scale response in an online study, whereas participants were pouring liquids in Experiment 1. However, this may point to a more interesting question of moderation, where it may be that some individuals are particularly vulnerable to the effects of fluency and Experiment 2 exemplifies this. Future research should examine for whom fluency effects are most prevalent. For example, perhaps individuals with low numeracy depend more on lexical information, and may be more impacted by fluency effects.

This research further extends the research on processing fluency, because it demonstrates that fluency not only influences consumers' evaluations, but also their behavior (Alter & Oppenheimer, 2006; Landwehr et al., 2011). In contrast to previous studies, the two experiments show that high processing fluency may lead to negative behavioral consequences that may jeopardize people's health. The indirect effect of drug name on dosage through hazardousness was markedly robust, as we found no indication that it was moderated by either type of drug (herbal vs. synthetic) or type of patient (self vs. child). However, though care was taken to create the dosing situation as realistic as possible (e.g., by letting participants pour their medi-

[4] See footnote 3.

cine), we used a nonpatient sample and a hypothetical scenario in both studies. This approach allowed us not only to study how drug name fluency impacts dosing behavior, but also provided us with a degree of experimental control over potential boundary conditions of the effect (e.g., dosing for oneself or for a child); this is something that is not typically feasible or ethical using real patients. However, we cannot rule out the possibility that the hypothetical behavior in our experiment may differ from people's actual dosing behavior in real life. Examination of real world data would be interesting for further investigation of whether the influence of a drug name's fluency on dosing is a robust finding and can be detected in naturalistic settings and clinical samples. It should also be acknowledged that the present study used self-report measures of familiarity and affect. Future studies might emphasize discovering whether objective measures of familiarity (e.g., via pupil response; Kafkas & Montaldi, 2015) and affect (e.g., via facial electromyography; Cannon, Hayes, & Tipper, 2010; Topolinski, Likowski, Weyers, & Strack, 2009; Winkielman & Cacioppo, 2001) yield similar results.

This research has important implications for health care. A large body of research suggests that parents and caregivers make frequent errors when administering medications to children (Miller, Robinson, Lubomski, Rinke, & Pronovost, 2007; Yin et al., 2008); and children, with their immature organ and immune systems and small size, are particularly vulnerable to biases in dosing (Yin et al., 2008). The results of this study demonstrate that a drug name's fluency might contribute to such biases, because the effect was found not only for dosing decisions for oneself, but also when participants had to make dosing decisions for a child. Recommended daily doses (as indicated by the package insert) of many drugs allow for some leeway in the dosing schedule for drugs; as a result, biases in dosing are likely. Particularly when both time periods and drug dosage are presented as ranges (e.g., "10–20mL every 4–6 hours") small biases in drug dosage may compound over time. Brand managers and other professionals involved in the brand naming process should be alert regarding the potential impact of a name's fluency on consumers' evaluations and dosing behavior. A drug with strong side effects and a high potential for misuse should not be branded with a fluent name, as this may encourage people to believe that the drug is innocuous and may lead to overdosing. Disfluent drug names, on the other hand, may sensitize people to risks, and could motivate them to pay closer attention to warnings and package inserts. If a drug's efficacy is closely tied to its dose, biases in dosing could be prevented by using dosing forms that minimize dosing errors, such as unit-dose packaging.

An important direction for future research would be to examine if health care professionals, such as physicians and pharmacists, are influenced by the fluency of drug names as well. Because fluency effects can happen unintentionally and are hence hard to correct (Graf & Landwehr, 2015), it is possible that even experts' dosing decisions are biased, with severe consequences for their patients.

In sum, this research suggests that a drug name's fluency is a powerful driver of people's dosing behavior. This effect was found both for natural and synthetically produced drugs, and also occurs when consumers chose a dosage on behalf of another person. Because drug poisoning is a serious public health problem, brand managers should attend to the potential consequences of their naming decisions for specific drugs, and more research on the 'dark side' of fluency is warranted.

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