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Sensible Moves

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VRIJE UNIVERSITEIT

Sensible Moves

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad Doctor aan
de Vrije Universiteit Amsterdam,
op gezag van de rector magnificus
prof.dr. L.M. Bouter,
in het openbaar te verdedigen
ten overstaan van de promotiecommissie
van de faculteit der Psychologie en Pedagogiek
op woensdag 9 maart 2011 om 11.45 uur
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door

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Chapter 1

Introduction

Fluency. When asking the Oxford English Dictionary about the meaning of the word “fluency”, it offers:

1. *Affluence, copiousness, abundance*
2. (a) *A smooth and easy flow; readiness, smoothness*
(b) *Absence of rigidity; ease*
3. *Readiness of utterance, flow of words*

This dissertation is concerned with the second suggested meaning: fluency as “a smooth and easy flow”, a feeling of “ease”. More precisely, in the work underlying this dissertation I examined different aspects of *processing fluency*. In psychological terms, processing fluency refers to the ease with which new information can be processed. For example, a letter can be written in a font that is **easy to read** or in a font that is *more difficult to read*, making the information in the letter relatively easy or difficult to process. Similarly, we might be able to process information more fluently if we have seen it before. Or when learning a new

language, some words might be easy to pronounce and some might be more difficult, for example, think of the Dutch words *kip* (chicken) and *angstschreeuw* (scream of fear). Overall, whenever it is easy to process such stimuli, we talk about processing fluency whereas disfluency refers to situations when our processing is less smooth.

As you might have realized from these examples, processing fluency is not about *what* is being processed, but about *how* something is processed. Rather than being concerned with the content of our cognitions, processing fluency refers to a *metacognitive* experience, a momentary feeling about how our thinking processes are going. Whereas the above examples of processing fluency mainly involve perceptual processes as when reading an easy- or difficult-to-read letter, the research underlying this dissertation examined whether such fluency experiences can equally be triggered by actual physical interactions with one's environment – or by a mental simulation of such interactions. For example, imagine how it feels to use your dominant hand to unlock your apartment door as compared to using your non-dominant hand.

1.1 Why Investigate Processing Fluency?

You might think that, naturally, if something is easy to read, it's easier to process. Similarly, you're skilled to use your dominant hand more than your non-dominant hand, so naturally, that should produce a feeling of "ease". So why is it interesting or important to investigate processing fluency? Fascinatingly, in all of these examples, the feeling of ease we experience also exerts an influence on how we judge the content of what we are processing. For example, individuals who have to grade hand-written essays assign better grades if the handwriting is easy to read than if it is difficult to read (Greifeneder et al., 2010). In other words, the *same* essay is judged differently depending on how easy the information is to process. Generally, the fluency with which we can process information fundamentally affects our evaluation of and our feelings

towards the information. For instance, a menu can be easy or difficult to read, stock names can be easy or difficult to pronounce, or aphorisms can rhyme vs. not. A vast amount of research shows that such ubiquitous cues and their resulting fluency experience affect judgments, as the dishes on the difficult-to-read menu are thought to require more effort (Song & Schwarz, 2008b), easy-to-pronounce stock names outperform difficult-to-pronounce stock names (Alter & Oppenheimer, 2006), and rhyming aphorisms seem truer than non-rhyming aphorisms (McGlone & Tofiqbakhsh, 2000). Processing fluency can further lead to feelings of familiarity (e.g., Whittlesea & Williams, 1998) and feelings of confidence (e.g., Novemsky, Dhar, Schwarz, & Simonson, 2007).

In general, the easier it is for an individual to process a particular stimulus, the better this stimulus is liked (cf. Alter & Oppenheimer, 2009; Schwarz, 2004; Schwarz, Song, & Xu, 2008). This has been most notably shown for perceptual fluency. For example, Reber and colleagues (Reber, Winkielman, & Schwarz, 1998) conducted experiments in which they manipulated the ease of processing for certain stimuli by priming their visual contours prior to showing them. Having seen the contour of a stimulus, participants should be able to process the stimulus itself more easily. As expected, this processing ease then influenced participants' liking ratings: They liked the stimuli better after a matching contour prime than after a mismatching prime.

Moreover, the experience of fluency seems to lead to a general positive affective response, as illustrated by another set of experiments (Winkielman & Cacioppo, 2001): Participants saw line drawings which were again preceded by matching or mismatching primes. While viewing the drawings, participants' facial expressions were recorded using electromyography (EMG) to measure the zygomaticus major (cheek) and corrugator supercilii (brow) muscle activations, and after viewing each drawing, participants explicitly rated their affective response toward it. Easy-to-process stimuli, namely those following a matching prime, elicited a positive affective response as indicated by an increase in the zygomaticus major activity (the muscle involved in smiling), whereas

difficult-to-process stimuli did not. The participants' explicit evaluations of the stimuli mirrored these physiological findings.

Thus, overall, it seems like the fluency or ease with which individuals can process information influences their liking of it, their affect in general, and even a range of other judgments related to the information, such as its truth value. Thus, although it is commonly assumed that individuals use objective information to judge information, the research on fluency suggests that a subtle and seemingly irrelevant cue as one's ease of processing the information, can exert an influence on judgments and decision making. Such fluency signals have been suggested to be *hedonically marked*, in other words, fluency is experienced as something positive, "because it says something about a positive or negative state of affairs, either in the world or within the cognitive system" (p. 203, Winkielman, Schwarz, Fazendeiro, & Reber, 2003). Recent evidence suggests that fluency might not merely be positive, but it might more generally signal that something is particularly informative or usable (Häfner & Stapel, 2010).

In sum, fluency experiences are *functional* in that they inform us about ongoing cognitions. Therefore, it is relevant to study both the conditions under which such fluency experiences arise and the potential consequences of these experiences on judgments, decision making, our cognitive processes in general, and even behavior. The research described in this dissertation contributes to various aspects of these research questions.

1.2 Fluency From the Motor System

As the examples above already suggest, it seems like any variable that can facilitate information processing produces feelings of fluency (see also Alter & Oppenheimer, 2009), for example, readability, pronounceability, and rhyming all had effects on how the information was judged.

In the current research, I was interested in whether such fluency experiences can also arise as a result of actual, anticipated, or simulated interactions with one's environment.

The premise underlying all of the empirical work presented in this dissertation is that any perceptual or cognitive process serves action (cf. Clark, 1997; Hommel, Müsseler, Aschersleben, & Prinz, 2001; Prinz, 1997; E. R. Smith & Semin, 2004). For example, when we see a cup standing on the table in front of us, we don't just think "*There is a cup standing on the table.*", but on some (probably unconscious) level, we also think about what we could *do* with this cup, for example, how we could pick it up. Tucker and Ellis (1998) refer to this as the *potentiation* of possible actions, implying a sense of preparedness to act. For example, when the cup's handle is oriented to the right, a right-hand grasp is easier than a left-hand grasp. Unconsciously, we therefore automatically potentiate a right-hand grasp (more than a left-hand grasp), meaning that when we then actually act on the cup, we are faster when using the right hand than the left (Tucker & Ellis, 1998). Importantly, this is not merely an effect of being right- or left-handed, but it works equally on the other side, such that a left-hand grasp is potentiated when the cup's handle is oriented toward the left.

The idea that our perception prepares for action in this sense is best accounted for by economic theories of perception (cf. Gibson, 1979; see also Proffitt, 2006). Accordingly, perception serves action in that it informs about the opportunities for possible actions and about the costs associated with these actions. Gibson's ecological approach to perception (1979) proposes that the mere perception of an object leads to the activation of possible actions one could perform with this object. He referred to such perceived action opportunities as *affordances*. Thus, in the example above, a right-hand grasp is said to be more afforded than a left-hand grasp when the cup's handle is oriented toward the right. Proffitt (2006) suggested that such affordances in visual perception are adaptive, because by informing us not only about the opportunities for

action, but also about the associated costs, energy can be saved – or at least used in the most efficient manner.

The following two chapters of this dissertation deal with the question whether such action affordances can give rise to fluency experiences paralleling those triggered by simple perceptual manipulations as in the examples given above (e.g., the readability of an essay). Based on the assumption that fluency experiences and their affective consequences arise as a result of feeling that one’s processing is easy, smooth, and effortless, I predicted that similar effects should be found when acting in line with the affordances perceived in the environment. If it is true that possible and likely actions are automatically potentiated upon the perception of an object (Gibson, 1979; Tucker & Ellis, 1998), acting in line with the potentiated actions should be notably easier than performing a different action and should therefore produce a feeling of fluency. Moreover, in analogy to the effects of perceptual fluency, the experience of such *motor fluency* should also affect other outcome variables. In other words, grabbing the cup which is oriented toward the right with your right hand should not only be easier, but it should also *feel better*. Specifically, mirroring previously established effects of processing fluency, I hypothesized that:

1. One should like an object better if it is easier to interact with this object.
2. One should feel more positive after acting in line with perceived affordances than after acting against such affordances.
3. Acting in line with perceived affordances should generally produce a feeling of processing fluency.
4. One should prefer an object over an alternative if one anticipates an easier interaction with it.

Recent research has provided initial support for Hypothesis 1: In an experiment, participants moved simple household items from one posi-

tion to another – either with an obstacle in the way, therefore disfluently, or without an obstacle, therefore fluently (A. E. Hayes, Paul, Beuger, & Tipper, 2008). They then rated how much they liked each object compared to other imaginable objects of its kind. Participants liked the objects from fluent actions better than the objects from disfluent actions. Thus, the physical dynamics of interacting with the objects affected the extent to which participants liked them. In support of Hypothesis 2, Cannon, Hayes, and Tipper (2010) showed that actions congruent with perceived affordances can produce positive affect. Participants had to classify whether objects belong into the kitchen or the garage. Similar to the above example of the cups, these objects were portrayed with a left- or rightward orientation, therefore better affording a left- or right-hand grasp. In correspondence to the perceptual fluency effects by Winkielman and Cacioppo (2001), Cannon et al. (2010) found that grasp-compatible responses lead to an increased activity of the zygomaticus major muscle, suggesting that participants (implicitly) experienced positive affect.

In Chapter 2 of the current dissertation, I aimed to replicate this with another measure of affect. Furthermore, I sought to find support for Hypothesis 3. In two experiments, I employed a similar stimulus-response paradigm, in which participants had to indicate whether an object was portrayed upright or inverted. In addition to the invertedness dimension, the objects were portrayed with a left- or rightward orientation (cf. Tucker & Ellis, 1998). Whereas previous research has convincingly demonstrated that actions congruent with perceived affordances are indeed easier (Tucker & Ellis, 1998, 2001, 2004; Symes, Ellis, & Tucker, 2007), I thus aimed to show that – similar to other fluency experiences – they also produce a positive feeling, and more importantly, that they are indeed based on the experience of subjective processing fluency. The findings of both experiments support the idea that processing fluency can be grounded in the motor system.

Chapter 3 of this dissertation addresses Hypothesis 4. I predicted that when one is faced with two action alternatives, the more fluent

alternative should be preferred. Imagine, for example, that you are going to play table-tennis and you can choose the side to play at. Imagine further, that you are standing by the net, exactly in the middle between the two sides. All other things being equal, it really shouldn't matter what side of the table-tennis table you choose. However, I argue that if perception is truly action-driven, one is likely to run a *motor simulation* of each action alternative (cf. Witt & Proffitt, 2008). Thus, one should (unconsciously) simulate what it would be like to go to either side of the table-tennis table. I propose that in a situation like the table-tennis example, the simulation will also include your play-hand. Thus, if you are right-handed, it should seem easier to go to the right side of the table because merely extending the arm on the side of your play-hand already covers half of the distance to get to that side. Chapter 3 describes two experiments using a paradigm which involved exactly this choice between playing on the left and the right side of a table-tennis table. I predicted that the simulation of the different action alternatives is enough to create an affordance situation, which can produce fluency effects, such that the easiest – the least costly – course of action is preferred.

Initial evidence suggests that preference judgments can be grounded in the motor system (Beilock & Holt, 2007; Bergh, Vrana, & Eelen, 1990): Typists repeatedly chose one of two letter dyads, which were manipulated, such that typists would usually type the two letters with the same hand (e.g., FV) or with different hands (e.g., FJ). They preferred different-hand letter dyads over same-hand letter dyads, suggesting that simulating different-hand dyads is more afforded than simulating same-hand dyads, because the associated action is easier.

Chapter 3 poses an important extension of the previously outlined function and characteristics of affordances in determining fluency outcomes. First, the mere anticipation of a fluent (inter)action should be enough to drive preferences. Second, the derived affordances should differ as individuals' bodily capabilities differ. Thus, what should seem fluent to one individual and therefore be preferred, might not be fluent

for another individual. For example a right-handed person should prefer the right side of the table, but a left-handed person should prefer the left. Furthermore, when contextually constraining an individual's action capabilities, for example, by instructing right-handed individuals to imagine playing with their left hand, the simulated affordance structure should change accordingly, leading to a different preference decision. In line with this, a growing body of research suggests that a person's contextual action capabilities influence perception. For example, hills look steeper when carrying a heavy backpack (Bhalla & Proffitt, 1999) or targets look further away when throwing heavy balls to them than when throwing light balls to them (Witt, Proffitt, & Epstein, 2004). My findings of Chapter 3 suggest that individuals make use of physical cues – affordances – to derive preferences and that these cues are situated and emerge within the dynamics between the individual and the environment.

1.3 Fluency from Multimodal Conceptual Thought

Overall, the research discussed in Chapters 2 and 3 suggests that fluency experiences can be triggered by the motor system. Smooth interactions with objects feel fluent and produce positive affect and individuals prefer actions for which they anticipate fluency. These findings hence support the view that perception is situated and action-driven and that even preferences are prone to such action effects (cf. Prinz, 1997; E. R. Smith & Semin, 2004).

However, one might argue that while this applies to perception in such concrete situations, the reported research is silent on the role of actions or the body in *conceptual thought*, for instance in language comprehension. Reading a sentence like “*The lemon tastes sour.*” implies no real, physical interaction with or action on an object or the environment. Nevertheless, perceptual theories of knowledge propose that

even the way we understand language and how we mentally represent concepts is in the service of perception and action – and therefore heavily contingent on perceptual variables (Barsalou, 1999; Glenberg, 1997). Ultimately, the question about the underpinnings of conceptual thought is the question of how meaning is mentally represented and derived. According to perceptual theories of knowledge, concepts must be grounded in physical experiences. Glenberg (1997), for instance, argued that “we understand language by creating embodied conceptualizations of situations the language is describing” (p. 12). Similarly, Barsalou’s (1999) theory of perceptual symbol systems (PSS) assumes that we represent concepts by partially re-enacting experiences we had with them. Importantly, PSS argues that these re-enactments are componential, dynamic, and modality-specific. Thus, depending on the situation at hand, the meaning – and thus the representation – of a concept is dynamically adapted. For example, when offered a glass of lemon juice, one might particularly think about how lemons taste sour. However, while arranging a lemon with other fruits to prepare a nice fruit basket, the current representation of the concept “lemon” might include its shape (“where would the lemon fit”) or its color (“it might look nicer next to a red apple than next to a yellow banana”) rather than its taste. In this sense, conceptual thought can be conceived of as just as situated, perceptual, and action-driven as actual physical interactions (cf. Barsalou, 2003; Yeh & Barsalou, 2006; Zwaan, Madden, Yaxley, & Aveyard, 2004).

Therefore, the research discussed in Chapter 4 explored how fluency experiences can arise from conceptual thought. Particularly, the presented research is based on the assumption that language comprehension is situated and modality-specific. Thus, for example, when reading the sentence “*The lemon tastes sour.*”, our representation of a lemon should primarily include the gustatory modality, whereas the representation of the sentence “*The lemon is yellow.*” should primarily include the visual modality. Evidence for such modality-specific processing comes from experiments in which participants repeatedly read such sentences and had to verify whether the property (e.g., “sour”) is typically true of the concept. Interestingly, when two subsequent sentences involved the same

modality, for example, “*The lemon is sour.*” followed by “*The sandwich is savory.*” participants processed the sentences faster than when the two subsequent sentences involved different modalities, for instance when the sentence “*The lemon is sour.*” is followed by the sentence “*The water is wet.*” (Pecher, Zeelenberg, & Barsalou, 2003).

Although prior research has convincingly demonstrated these processing costs associated with modality switching in conceptual thought (Pecher et al., 2003; Pecher, Zeelenberg, & Barsalou, 2004; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008), I propose that including several modalities in the representation of a concept will make it easier to derive the concept’s meaning than if fewer modalities are involved in the concept’s representation. We should better be able to understand what a lemon is, if we simultaneously know that it is yellow and tastes sour, a visual and a gustatory property, than if we know that it is yellow and oval, two visual properties. Therefore, I argue that a concept representation involving several different modalities becomes semantically richer than a representation involving only a single modality. In other contexts, semantic richness has been linked to processing fluency (Gill, Swan, & Silvera, 1998; Myers, O’Brien, Balota, & Toyofuku, 1984; E. E. Smith, Adams, & Schorr, 1978). Thus, as a concept’s representation becomes richer, it should become more accessible, leading to the experience of processing fluency. After processing concepts within a multi-modal context, I hence expected to find an influence of this fluency experience on affective variables. Particularly, I hypothesized that:

5. Concepts encoded within a multi-modal processing context gain more meaning and thus a richer semantic representation.
6. Multi-modality processing generates a positive feeling.
7. A concept encoded with a number of multi-modal properties is liked more than a concept encoded with properties from a single modality.

I addressed these hypotheses in Chapter 4. My findings are in line with situated, embodied accounts of cognition, which assume concept representations to be dynamic. The chapter further provides experimental evidence that this representational flexibility has implications for an individual's processing experience per se.

1.4 Fluency and Self-Regulation

The different lines of research outlined so far have in common that fluency is seen as a functional property of our processing experience. It can inform us about the ease with which we can expect to interact in a situation or with which we can derive meaning from a sentence. In Chapter 5 of this dissertation, I take a different approach to directly assess the functional value of processing fluency. In most of the research on processing fluency, the experiments are designed such that a fluent condition is compared to a disfluent condition. Therefore, it is unclear whether the effects reported in such experiments are due to an experience of fluency or actually due to an experience of disfluency. Nevertheless, most results are interpreted as a function of fluent processing, such that information, for example, becomes liked more, seems more true, or is more valued. I don't deny the possibility that experiencing fluency can trigger genuine positive affect – and the physiological data reported by Winkielman and Cacioppo (2001) support this possibility.

However, I assume that fluency experiences are generally informative about one's ongoing cognitions. Therefore, particularly the experience of *disfluency* should be relevant for self-monitoring and self-regulation. Disfluency indicates that the current situation is somehow problematic, that something in the current processing context “*isn't going right*”. Therefore, in line with theories of situated cognition (cf. Schwarz, 2002; E. R. Smith & Semin, 2004), which assume that our cognitive processes are tuned to situational requirements, disfluency might signal the need to adapt one's current processing style (cf. Schwarz, 2002; Schwarz &

Clore, 1996), for example to invest more effort or to adapt a different processing strategy. In sum, I propose that particularly the metacognitive feeling of disfluency provides an internal feedback signal about ongoing cognitive processes which serves self-control (cf. Metcalfe & Shimamura, 1994; Mazzoni & Nelson, 1998; see also Winkielman, Schwarz, & Nowak, 2002). Drawing on the resource model of self-control (Muraven & Baumeister, 2000), I expected that if disfluency indicates the need to upregulate self-control, the limited resources available for self-regulation in general would be unavailable on a subsequent task. I therefore hypothesized that:

8. Experiencing disfluency depletes self-regulatory resources. Therefore, an individual is less able to exert self-control after an experience of disfluency.

Chapter 5 discusses two experiments which address this hypothesis. After a manipulation of perceptual fluency, participants' capacity for self-control was assessed. My findings corroborate the idea that fluency experiences are important for self-regulation.

1.5 Summary

The present dissertation is about different antecedents and consequences of processing fluency. While most research on processing fluency has investigated what happens “when thinking is difficult” (cf. Schwarz et al., 2008), Chapters 2 and 3 address what happens when “doing is difficult”. Particularly, I show that the intimate link between perception and action can give rise to fluency experiences when actions are congruent with perceived capabilities. Chapter 4 illustrates that although language comprehension is initially hampered when many different modalities are involved during processing, the resulting multi-modal concept representations ultimately facilitate the construction of meaning. Therefore, as

with any processing variable (cf. Alter & Oppenheimer, 2009), this facilitation produces fluency experiences.

The reported research is consistent with the idea that perception and cognition generally serve action (Hommel et al., 2001; Prinz, 1997; E. R. Smith & Semin, 2004). Therefore, fluency is functional in that it rewards easy – and hence energy-conserving – actions and processing (see Chapters 2 and 4) and in that it promotes such actions (see Chapter 3). Chapter 5 addresses a possible consequence of processing disfluency. If fluency experiences are about adapting one’s processing to the characteristics and requirements of the situation with the ultimate goal to preserve energy and act cost-effectively (cf. Proffitt, 2006), then the feeling of disfluency should signal the need to change something in the current situation. Chapter 5 therefore demonstrates directly that processing difficulty plays a role in self-regulation.

Thus, fluency experiences seem to be hedonically marked to reward the least costly course of processing or action, but equally, disfluency experiences seem to contribute to self-regulation by driving a cognitive and/or behavioral change. The current dissertation explores these issues within the experiences of sensorimotor fluency, anticipated action fluency, conceptual fluency, and perceptual fluency with outcomes on perceived fluency, affect, choice preferences, liking judgments for the targets of processing, and self-regulatory depletion.

Chapter 2

The Groove Move: Action Affordances Produce Fluency and Positive Affect

This chapter is based on:

Regenberg, N.F.E., Häfner, M., & Semin, G.R. (in press). The groove move: Action affordances produce fluency and positive affect. *Experimental Psychology*

Abstract

In two experiments we show that the experience of processing fluency can be grounded in the motor system. We manipulated whether responses in a stimulus-response paradigm were congruent or incongruent with the orientation of graspable objects. Besides the typical affordance effect (Tucker & Ellis, 1998), namely a reaction time advantage for responses made with the hand for which it would be easier to grasp the object, our results reveal that such visuo-motor congruence elicits positive affect when preceded by incongruent trials (Experiment 1). Experiment 2 demonstrates that individuals are aware of this fluency experience and can consciously report on it. Moreover, by manipulating the task contingencies, we show that the affordance effect itself can be modulated by the experience of processing fluency. Our results are in line with theories assuming a direct coupling between perception and action (Hommel et al., 2001; Prinz, 1997; E. R. Smith & Semin, 2004).

In many every-day situations, we like things better when they are easy to process or do. For example, we like a well structured talk that is easy to follow more than a badly structured presentation and we prefer buying tickets from a vending machine that is easy to use to one that requires a lot of cognitive effort. Generally, the fluency with which we can process information fundamentally affects our evaluation of and our feelings towards the information. Such processing dynamics can have an influence on measures of objective fluency, namely an objectively quantifiable processing advantage of fluent over disfluent stimuli (e.g., Reber et al., 1998; Tucker & Ellis, 1998), on measures of subjective fluency, such as a perceived feeling of ease (e.g., Song & Schwarz, 2008b), and on evaluative and affective measures, such as liking judgments of a target stimulus (e.g., Bornstein, 1989; Zajonc, 1968) or implicit mood measures (Winkielman & Cacioppo, 2001). Whereas most research on fluency has investigated fluency effects as triggered by information processing, in the present research, we explore whether fluency experiences can arise from *physical* interactions with objects. We demonstrate that physical interactions that are smooth and effortless have similar consequences, as they produce a cognitive processing advantage for the object and they elicit a positive affective response. Moreover, the goal of the present research is to show that these consequences indeed coincide with a meta-cognitive feeling of ease, namely the experience of subjective processing fluency.

Our research question hinges on the premise that cognition serves action (cf. E. R. Smith & Semin, 2004) and that therefore perception and action are ultimately linked. As similarly proposed by the ecological approach to perception (Gibson, 1979), we assume that the mere perception of an object leads to the activation of possible actions one could perform with this object. For example, when we see a coffee mug on the kitchen table, we automatically potentiate associated actions, such as grabbing it and picking it up. This has been convincingly demonstrated in experiments on the “affordance effect” with a stimulus-response (S-R) compatibility paradigm (Tucker & Ellis, 1998): Participants saw graspable household objects like mugs or frying pans and made judgments about whether they were upright or inverted using their left or right

hand. In addition to the invertedness dimension, the objects were displayed with a left- or rightward orientation. If the object's action possibilities, or affordances, are automatically potentiated, this should be reflected in a processing advantage on trials where the response hand is congruent with the object's horizontal orientation as compared to trials where the response hand is incongruent with the object's orientation. Indeed, participants responded faster when they made the response with the hand for which it would be easier to grasp an object, although this was irrelevant to the judgment. Further experiments have demonstrated that, in general, when we act congruently with an object's visual action affordances, as its orientation or size, these interactions are faster than when the performed actions are incongruent with the object's affordances (cf. Symes et al., 2007; Tucker & Ellis, 2001, 2004). These S-R compatibility effects illustrate how objective fluency, namely an objective processing advantage, can arise from the compatibility between perceived affordances and motor responses: When we act in line with such object affordances, our actions are noticeably easier than when we act against such affordances.

The aim of the current experiments is to show that over and above facilitating information processing, the perceived ease of interacting with our environment has also subjective consequences by triggering an affective response and a meta-cognitive feeling of fluency. First, we hypothesize that if actions are automatically potentiated upon the perception of an object, motor responses congruent with these actions should not only be measurably easier, that is, faster, but they should also elicit a positive feeling. Conversely, due to the increased amount of cognitive effort necessary to perform motor responses not in line with perceived action affordances, such S-R incompatibilities are likely to elicit a more negative feeling. Second, we hypothesize that the perceived ease of interacting with one's environment directly results in a meta-cognitive feeling, namely the subjective experience of processing fluency.

In general, previous research on fluency effects has suggested that such subjectively experienced outcomes are not necessarily directly as-

sociated with differences in objective processing fluency, but are instead the result of an experienced discrepancy between one's expected and actually experienced fluency of processing. For example, a classic effect of processing fluency is that fluently processed stimuli feel more familiar than disfluently processed stimuli (e.g., Jacoby & Whitehouse, 1989; Whittlesea, Jacoby, & Girard, 1990). However, Whittlesea and Williams (1998, 2000; Whittlesea, 2004) have demonstrated that the feeling of familiarity is not driven by the objective processing fluency per se, but instead arises when the processing fluency is unexpected in the particular task or context. In support of this discrepancy-attribution hypothesis, other subjective outcomes of processing fluency as preferences (S. Willems & Linden, 2006), truth judgments (Hansen, Dechêne, & Wänke, 2008), judgments of morality (Laham, Alter, & Goodwin, 2009), or attitude judgments (Hansen & Wänke, 2008) can be similarly moderated by expectations and the task context.

Therefore, in the context of an S-R compatibility paradigm, as the aforementioned affordance task, we expect that the experience of subjective processing fluency is driven by the discrepancy between one's actual processing fluency and the expected ease of processing as created by the current task context. We expect individuals to experience fluency and a positive feeling when S-R compatible trials follow S-R incompatible trials, thereby creating a discrepantly fluent experience as compared to stimulus sequences in which S-R incompatible trials follow S-R compatible trials, which should produce a feeling of discrepant disfluency and a more negative feeling state.

The idea that such dynamics of our interactions with the world influence how we feel finds ample support in the research on perceptual and processing fluency (cf. Winkielman et al., 2002, 2003). Fluency is usually conceptualized as the perceived ease of processing. The easier it is for an individual to process a particular stimulus, the better this stimulus is liked. This has been most notably shown for perceptual fluency. For example, Reber, et al. (1998) conducted experiments in which they manipulated the ease of processing for certain stimuli, e.g., by priming

their visual contours prior to showing them (Exp. 1). Participants liked the stimuli better in the easy processing conditions than in the more difficult processing conditions. Moreover, the experience of fluency seems to lead to a general positive affective response as captured by physiological measures (Winkielman & Cacioppo, 2001): Participants rated their affective reactions to line drawings, which were preceded by matching vs. mismatching primes, while facial expressions were recorded using electromyography (EMG) measuring the participants' zygomaticus major (cheek) and corrugator supercilii (brow) activations. Easy-to-process stimuli, i.e., those following a matching prime, elicited a positive affective response as indicated by an increase in the zygomaticus major activity, whereas difficult-to-process stimuli did not. The participants' explicit evaluations of the stimuli mirrored these physiological findings.

Overall, individuals seem to be sensitive not only to what they are processing, but also to how they are processing, such that variables that facilitate processing lead to increased liking for the target and/or positive affect. In the current research, we investigate whether such fluency is equally experienced when motor actions are facilitated through the perceptual features of a stimulus. Imagine a cup whose handle is oriented toward the right is standing in front of you. It should be easier to grab the cup with the right hand than with the left hand. We expect that the perceived ease of interacting with the cup when grabbing it with the right hand leads to a more positive feeling than when grabbing it with the left hand. In line with the discrepancy-attribution hypothesis outlined above, we expect this effect when the experienced processing fluency deviates from the processing fluency in the immediate task context and thereby becomes particularly salient. For example, the positive feeling should particularly arise when participants use their right hand to reach for the cup whose handle is oriented toward the right (S-R compatible) after having previously reached for other objects with their hands that were opposite to the objects' orientations (S-R incompatible). Thus, we expect the effect to be contingent on the current task properties and expectations.

Recent research has provided initial support for the idea that affective reactions can be influenced by motor fluency effects: In an experiment, participants moved simple household items from one position to another – either with an obstacle in the way, i.e., disfluently, or without an obstacle, i.e., fluently (A. E. Hayes et al., 2008). They then rated how much they liked each object compared to other imaginable objects of its kind. Participants liked the objects from fluent actions better than the objects from disfluent actions. Thus, the physical dynamics of interacting with the objects affected the extent to which participants liked them. Similarly, Cannon et al. (2010) showed that in a speeded categorization task S-R compatible responses to graspable stimuli lead to more positive implicit affect than S-R incompatible responses as measured by EMG of the zygomaticus major muscle. In the present work, we sought to show more directly that such S-R compatibility effects are indeed based on the experience of subjective fluency, i.e., that participants can report a meta-cognitive feeling of fluency.

In sum, our research is based on the premise that perception serves action such that perceiving objects automatically leads to an activation of possible motor actions. In an S-R compatibility paradigm, during which action affordances to objects are activated, this should be reflected in an objective processing advantage when the required motor response matches the most activated affordances, as illustrated by the classic affordance effect (Tucker & Ellis, 1998). Second, we expect that discrepant visuo-motor fluency is accompanied by a more positive feeling state than discrepant disfluency. Finally, we aim to provide direct evidence for the assumption that these affective consequences are grounded in a meta-cognitive feeling of processing fluency.

2.1 Experiment 1: Affective Consequences of Visuo-Motor Fluency

We used an affordance task (Tucker & Ellis, 1998, Experiment 1) to explore whether compatibility between the perceptual features of the stimuli, namely their orientation, and their required motor response can produce subjective fluency effects. Particularly, we investigated the affective consequences of this visuo-motor fluency. The experimental task consisted of sequences of affordance task trials, which were either discrepantly fluent, discrepantly disfluent, or neutral. We hypothesized that when participants execute a series of S-R compatible responses after a series of S-R incompatible responses (discrepant fluency), they experience more positive affect than when performing a series of S-R incompatible responses after a series of S-R compatible responses (discrepant disfluency). To assess the hypothesized affective consequences, participants evaluated the valence of Chinese ideographs (cf. Murphy & Zajonc, 1993) after series of four S-R compatible or four S-R incompatible actions. We expected participants to be more likely to assign a positive valence to the Chinese ideographs after performing discrepantly fluent than after performing discrepantly disfluent sequences.

2.1.1 Method

Participants

Eighteen university students (three male) participated in the experiment for a small monetary reward or course credit.

Stimuli and affordance task

We created images of 32 common household objects with an intrinsic orientation toward the left or right through a graspable handle, for example, cups, jugs, and coffee pots. The objects were approximately 500×500 pixels large and displayed in gray-scale on a white background. Each image was mirrored to create four different versions: a leftward and a rightward orientation and standing upright or inverted. Thus, we had 23×2 (orientation) $\times 2$ (invertedness) = 92 different images. During the affordance task, participants saw one object at a time and indicated whether the object was upright or inverted by responding with their left or right hand. Additionally, the objects appeared with a left- or rightward orientation.

Design and procedure

Participants always responded to series of four affordance task trials. Within these four trials either all required an S-R compatible response or an S-R incompatible response. The response hands and the object orientations were counterbalanced, such that two responses were to be made with the left hand and two with the right hand and two objects had a leftward and two a rightward orientation. After each such series, participants judged whether the meaning of a Chinese ideograph was likely to be negative or positive on a vertically displayed 6-point scale from 1 (“extremely negative”) to 6 (“extremely positive”). Additionally, we manipulated the response mapping within-participants across two experimental blocks, i.e., whether participants made the “upright” judgment with their left hand and the “inverted” judgment with their right hand or vice versa. They saw a total of 20 S-R compatible and 20 S-R incompatible series within each mapping, i.e., a total 2 (mapping) $\times 40$ (series of affordance task trials) $\times 4$ (trials per series) = 320 affordance task trials.

We chose this design to keep the task as simple as possible: Participants always performed only four trials before they answered the question about the Chinese ideograph. However, as we expect the affective consequences of visuo-motor fluency to arise as a result of a *discrepant* fluency experience, we analyzed the data in terms of sequences of discrepant fluency (a series of four S-R incompatible trials followed by a series of four S-R compatible trials, 25.2% of all sequences), discrepant disfluency (a series of four S-R compatible trials followed by a series of four S-R incompatible trials, 24.3% of all sequences), and neutral control sequences (two series of S-R compatible or S-R incompatible trials following each other, 50.5% of all sequences).

2.1.2 Results

Response times and accuracy during the affordance task

We analyzed the reaction time data in a 2 (mapping: left-hand: upright vs. right-hand: upright) by 3 (fluency sequence: discrepantly fluent, neutral, discrepantly disfluent) repeated measures ANOVA while excluding errors and reaction times more than 2 SD from the respective condition mean. The analysis revealed only a trend for the expected affordance effect, $F(2, 34) = 2.37$, $p = .107$, $\eta_p^2 = .123$. Participants responded slightly faster to discrepantly fluent sequences ($M = 676.87$, $SD = 112.87$) than to discrepantly disfluent sequences ($M = 695.10$, $SD = 115.53$), $F(1, 17) = 2.65$, $p = .122$, $\eta_p^2 = .14$. Participants' responses did not differ between fluent and neutral sequences ($M = 677.51$, $SD = 120.08$), $F(1, 17) < 1$, but participants were faster on neutral than on disfluent sequences, $F(1, 17) = 4.73$, $p = .044$, $\eta_p^2 = .218$. No other effects emerged. A parallel 2 (mapping) \times 3 (fluency sequence) analysis of participants' accuracy rates yielded no effects, main effect of fluency: $F(2, 34) = 1.14$, $p = .331$, $\eta_p^2 = .06$, both other F s < 1 , rendering a speed-accuracy trade-off unlikely.

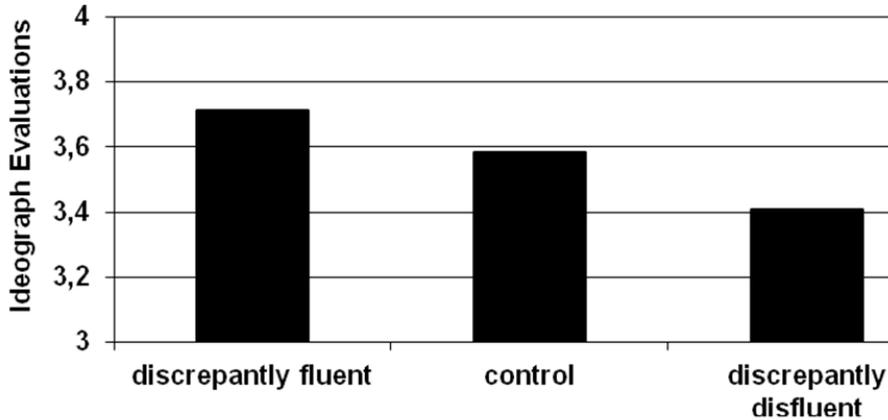


Figure 2.1: Mean evaluation of chinese ideographs (1 = “extremely negative”; 6 = “extremely positive”) as a function of the fluency sequence in Experiment 1.

Affect

Given the simplicity of the task, we excluded sequences in which participants committed an error on the affordance task and analyzed the Chinese ideograph evaluations in a repeated measures ANOVA as a function of the fluency sequence. The analysis yielded the expected effect of discrepant fluency, $F(2, 34) = 3.65$, $p = .037$, $\eta_p^2 = .18$. Planned comparisons revealed that participants evaluated the ideographs more positively after fluent sequences ($M = 3.71$, $SD = 0.32$) than after disfluent sequences ($M = 3.41$, $SD = 0.53$), $F(1, 17) = 4.93$, $p = .040$, $\eta_p^2 = .23$. Ideographs evaluated after neutral sequences were descriptively seen as more positive than after disfluent sequences and as more negative than after fluent sequences ($M = 3.58$, $SD = 0.44$), although the differences failed to reach significance, contrast fluent-neutral: $F(1, 17) = 1.80$, $p = .198$, $\eta_p^2 = .10$; contrast disfluent-neutral: $F(1, 17) = 3.00$, $p = .101$, $\eta_p^2 = .15$. The overall pattern is displayed in Figure 2.1.

2.1.3 Discussion

Participants performed an affordance task, in which series of compatible and incompatible responses followed each other, creating discrepantly fluent, discrepantly disfluent, and neutral task sequences. We assessed the hypothesis that discrepantly fluent motor responses would induce positive affect compared to discrepantly disfluent responses. As predicted, participants evaluated the meaning of Chinese ideographs as more positive after fluent than after disfluent sequences.

With our modified version of the affordance task we did not find a strong affordance effect on response latencies, although our results suggest differences in the expected direction: Participants responded slightly faster on discrepantly fluent trials than on discrepantly disfluent trials. Given the procedure of our task, it is not surprising that the reaction time effect overall is weaker than in previous research (cf. Tucker & Ellis, 1998) because participants always performed only four congruent or four incongruent affordance task trials in a row. Furthermore, due to the counterbalancing at least the fourth response will have become predictable, making it less likely to find reaction time effects.¹ Nevertheless, the experiment showed that the experience of visuo-motor fluency leads to a positive feeling when the fluency experience positively deviates from the immediately preceding experience.

2.2 Experiment 2: Objective and Subjective Fluency Experiences

We conducted a second experiment to examine the dynamics of the visuo-motor fluency effect found in Experiment 1. Whereas previous research has similarly shown that acting in line with action affordances

¹In fact, when conducting the same 2 (mapping) \times 3 (fluency) analysis on participants' reaction times while omitting the fourth trial of each series, the effect becomes slightly stronger, $F(2, 34) = 2.55$, $p = .093$, $\eta_p^2 = .13$.

has affective consequences (Cannon et al., 2010; A. E. Hayes et al., 2008), we designed this experiment to provide more direct evidence for the existence of motor-fluency effects by asking participants to report on their processing experience. We employed a similar affordance task paradigm as in Experiment 1, but increased the number of trials participants performed in a row to be able to replicate the typical affordance effect. We expected to find an effect of objective processing fluency, such that S-R compatible trials are responded to faster than S-R incompatible trials. Furthermore, we manipulated the affordance task sequences to be discrepantly fluent, discrepantly disfluent, or neutral. After every sequence participants answered how fluently they perceived the task to be going. We hypothesized that discrepantly fluent sequences lead to higher feelings of fluency than discrepantly disfluent sequences. Finally, we wanted to explore whether the emergence of objective fluency effects could also be modulated by the task context, such that it is most pronounced during discrepantly fluent sequences and least pronounced during discrepantly disfluent sequences.

2.2.1 Method

Participants

Fifty-two university students (41 female) participated in the experiment for a small monetary reward or course credit. The data of four participants were excluded from the analyses because their error rates on the affordance task exceeded 20%.

Design and procedure

Participants always responded to a series of twelve trials of the affordance task, which was introduced as a reaction time task, and then answered the question “To what extent do you think that the reaction

time task is going fluently?” by typing in the number corresponding to their answer on a vertically displayed scale from 1 = *not at all fluent* to 6 = *very fluent*. After a blank of 500 ms, they received the instruction that the reaction time task would now continue, which remained on the screen for 3500 ms. Then the next affordance task series started. Within these series, each object was presented until an answer was made or 3000 ms had elapsed. If no answer or an incorrect answer was made, participants heard a short warning signal. Then the next object appeared.

We manipulated the sequences within the twelve affordance task trials. In fluent sequences, the first four trials and the seventh and eighth trial required S-R incompatible responses, while the fifth and sixth trial and the last four trials of the sequence required S-R compatible responses. In disfluent sequences this pattern was reversed, such that the sequence started with S-R compatible responses and ended with incompatible responses. Finally, in the control sequences, the order was completely randomized per participant and per sequence. Importantly, within each type of sequence, there was an equal number of S-R compatible and incompatible responses. Furthermore, whether participants had to respond with their left or right hand was counterbalanced with the type of trial within each sequence, such that each sequence required six “upright” and six “inverted” judgments, i.e., six left-hand and six right-hand responses, three of each were congruent and three of which were incongruent with the object’s orientation.

Additionally, we manipulated the response mapping within-participants across two experimental blocks, i.e., whether participants made the “upright” judgment with their left hand and the “inverted” judgment with their right hand or vice versa. Within each mapping, participants saw five fluent, five disfluent, and five control sequences, thus a total of $2 \text{ (mapping)} \times 15 \text{ sequences} \times 12 \text{ trials per sequence} = 380$ trials of the affordance task, interrupted with 30 fluency questions. The order in which participants saw the objects was randomized per participant and the order in which participants did the two mapping blocks was counterbalanced. Participants did 20 practice trials of the affordance

Response Hand	Object Orientation	M(SD)		N
		RT	ACC	
right hand	rightward	591.49 (60.36)	.93 (.05)	48
	leftward	603.64 (61.28)	.93 (.05)	48
left hand	rightward	609.63 (58.66)	.92 (.05)	48
	leftward	603.64 (61.28)	.92 (.05)	48

Table 2.1: Mean response times (RT, Milliseconds) and accuracy rates (ACC, percentage) as a function of response hand and object orientation during the affordance task in experiment 2

task (ten congruent, ten incongruent) before each mapping block. In order to get participants used to the task, the congruent and incongruent trials were each presented in a row and we counterbalanced which came first between participants.

2.2.2 Results

Response times and accuracy during the affordance task

We removed all erroneous trials and reaction times more than 2 SDs from the respective condition mean. We then computed a 3 (sequence: fluent vs. disfluent vs. control) \times 2 (mapping: left-hand: upright vs. right-hand: upright) \times 2 (response: left-hand vs. right-hand) \times 2 (orientation: leftward vs. rightward) repeated measures ANOVA across the reaction times of all affordance task trials. We found the predicted interaction between response and orientation, $F(1, 47) = 15.99$, $p < .001$, $\eta_p^2 = .25$.² As the means in Table 2.1 illustrate, participants responded faster, when the orientation of the object matched the side of the re-

²The analysis further revealed a main effect of mapping, $F(1, 47) = 25.44$, $p < .001$, $\eta_p^2 = .35$: Participants made faster responses when they made the upright-judgment with their right hand and the inverted-judgment with their left hand ($M = 581.91$, $SD = 64.79$) than vice versa ($M = 610.30$, $SD = 57.21$) and a main effect of response, $F(1, 47) = 58.98$, $p < .001$, $\eta_p^2 = .56$: Participants responded faster with their right hand ($M = 585.02$, $SD = 58.92$) than with their left hand ($M = 606.61$,

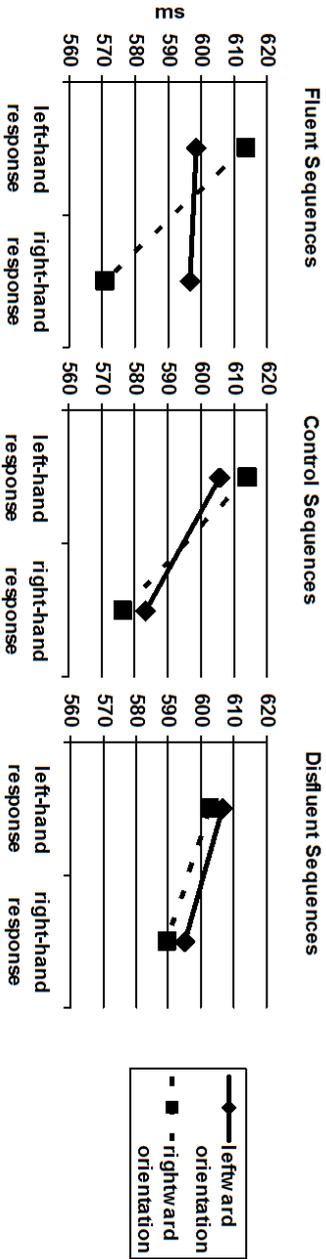


Figure 2.2: Mean response times in milliseconds as a function of fluency sequence, response hand, and object orientation during the affordance task in Experiment 2.

quired response. Interestingly, this interaction was further qualified by a three-way interaction between the fluency sequence, response, and orientation, $F(2, 94) = 5.37$, $p = .006$, $\eta_p^2 = .10$. As planned contrast analyses revealed, the expected affordance effect was most pronounced for fluent sequences, $F(1, 47) = 23.97$, $p < .001$, $\eta_p^2 = .34$, weaker for control sequences, $F(1, 47) = 4.17$, $p = .048$, $\eta_p^2 = .08$, and it disappeared for disfluent sequences, $F(1, 47) < 1$. Figure 2.2 illustrates this interaction.

An analogue 3 (sequence: fluent vs. disfluent vs. control) \times 2 (mapping: left-hand: upright vs. right-hand: upright) \times 2 (response: left-hand vs. right-hand) \times 2 (orientation: leftward vs. rightward) repeated measures ANOVA on the participants' accuracy rate during the task only yielded a main effect of mapping, $F(1, 47) = 6.05$, $p = .018$, $\eta_p^2 = .11$, indicating that participants were more accurate when making the "upright" response with their right hand and the "inverted" response with their left hand ($M = .93$, $SD = .04$) than vice versa ($M = .92$, $SD = .05$). Thus, we can rule out a speed-accuracy trade-off.

Perceived fluency

We hypothesized that the discrepantly fluent sequences would be experienced as more fluent than discrepantly disfluent sequences. We assessed this in a repeated measures ANOVA. Since participants might have derived the feeling of fluency from performing accurately rather than from the compatibility between the stimuli and their motor response, we controlled for accuracy in the analysis. It yielded the expected main effect of perceived fluency, $F(2, 92) = 4.29$, $p = .016$, $\eta_p^2 = .09$: Participants perceived the affordance task as most fluent after fluent sequences ($M = 4.47$, $SD = 0.81$) and about equally fluent after disfluent

$SD = 58.70$). Furthermore, interactions between mapping and response, $F(1, 47) = 17.95$, $p < .001$, $\eta_p^2 = .28$ and between fluency and response, $F(2, 94) = 5.17$, $p = .007$, $\eta_p^2 = .10$ emerged. As these effects are not relevant to our hypotheses we will not discuss them further.

($M = 4.39$, $SD = 0.87$) and control blocks ($M = 4.38$, $SD = 0.88$). Planned contrasts indicated a significant difference between fluent and disfluent sequences, $F(1, 46) = 6.31$, $p = .016$, $\eta_p^2 = .12$, and between fluent and control sequences, $F(1, 46) = 6.80$, $p = .012$, $\eta_p^2 = .13$. The difference between disfluent and control sequences was not significant, $F(1, 46) < 1$.

Furthermore, there was a main effect of participants' overall accuracy on the affordance task, $F(1, 46) = 10.50$, $p = .002$, $\eta_p^2 = .19$: The more accurate participants were the more they perceived the task as fluent. More interestingly, this was qualified by an interaction between participants' accuracy and the fluency sequences, $F(2, 92) = 4.09$, $p = .020$, $\eta_p^2 = .08$: For any kind of sequence, the more accurate participants were, the more they thought the task went fluently. However, this was most pronounced for disfluent, $t(45) = 3.36$, $p = .002$, $\eta_p^2 = .20$, $B = 9.21$, and control sequences, $t(45) = 3.63$, $p = .001$, $\eta_p^2 = .22$, $B = 9.88$, whereas accuracy played a smaller role for fluent sequences, $t(45) = 2.23$, $p = .031$, $\eta_p^2 = .10$, $B = 5.95$.

2.2.3 Discussion

Performing actions in congruence with perceived action affordances lead to faster reaction times, i.e., an objective processing fluency, and to the experience of a feeling of fluency – when the experienced fluency deviated from the expected task contingencies. This is in line with our hypothesis that visuo-motor fluency effects can arise from the compatibility between perceived action possibilities and motor responses. As in previous research on the affordance effect, participants responded faster when the required response hand and the object's orientation were congruent than when they were not. Interestingly, this was qualified by the fluency context in which the trials appeared. When the task was discrepantly fluent, the affordance effect was enhanced compared to control sequences, whereas it was diminished when the task was discrepantly disfluent. This finding suggests that even objective fluency effects on

a low processing level might be modulated by the task context. As hypothesized, this was mirrored in participants' self-reported feelings of fluency. Furthermore, the interaction between the fluency sequences and participants' accuracy on the task in predicting feelings of fluency suggests that individuals use several sources to derive and report their experience of fluency. If participants experience visuo-motor disfluency, they base the perceived fluency judgment primarily on their accuracy. If they perceive visuo-motor fluency, they base this judgment significantly less on accuracy. In other words, the experience of visuo-motor fluency can override – or at least attenuate – the to be expected effect of accuracy on perceived fluency.

2.3 General Discussion

In two experiments we demonstrated that the congruence of perceptual features of an object, as the orientation of its handle, and a motor response made toward the object lead to visuo-motor fluency. Specifically, we showed that such congruence can give rise to objective fluency, to a subjective feeling of fluency, and to a more positive feeling state compared to incongruence. In Experiment 1 participants judged the meaning of Chinese ideographs as more positive after discrepantly fluent affordance task sequences than after discrepantly disfluent sequences. These results mirror the fluency effects of other processing variables that don't involve the motor system on affective responses (cf. Harmon-Jones & Allen, 2001; Reber et al., 1998; Winkielman & Cacioppo, 2001; Winkielman et al., 2002, 2003) and are in line with recent research showing an association between fluent movements and positive stimulus evaluations (A. E. Hayes et al., 2008) and positive affect (Cannon et al., 2010). To demonstrate that these affective consequences are indeed the result of a fluency experience, we assessed participants' feeling of fluency more directly in Experiment 2. Our findings indicate that individuals are aware of the processing dynamics that arise from the interaction between perceiving affordances and acting on them and

as a result experience subjective fluency: Participants reported that the task was going more fluently after discrepantly fluent trials than after discrepantly disfluent trials. To our knowledge, this is the first direct evidence that visuo-motor congruence indeed leads to a meta-cognitive feeling of fluency.

In Experiment 2 we further replicated the expected objective fluency effect: As in previous research (Tucker & Ellis, 1998, 2001, 2004; Symes et al., 2007) participants showed an actual processing advantage when perceptual features of the stimulus were compatible with the required motor response. Moreover, we showed that this processing advantage can be qualified by the immediate task context: It was evident only when the affordance task became easier because a series of compatible trials followed a series of incompatible trials or when it remained on an equal difficulty level, but the effect was attenuated when the task became increasingly difficult because a series of incompatible trials followed a series of compatible trials. The idea that the task context or (implicit) task expectations can modulate such low-level visuo-motor processing effects is intriguing and raises the novel question to what extent higher-order cognitive functions can generally influence visuo-motor processes that are assumed to be automatic as the potentiation of grasp types or possible action components (cf. Tucker & Ellis, 1998).

Overall, our data thus support theories assuming a direct coupling between perception and action (Hommel et al., 2001; Prinz, 1997; E. R. Smith & Semin, 2004): Perception serves action by preparing possible and likely behaviors. The affordance effect holds that when seeing an object, we automatically think about how we could interact with it. Our results show that when we then act in congruence with such affordances, this is not only easier and faster, but we also experience fluency and feel better. According to the hedonic marking hypothesis of fluency (Winkielman et al., 2003), such experiences can be useful in that they allow us to monitor and evaluate our current processing dynamics, rewarding easy-to-process information that facilitates cognitive processes. In sum, the present experiments are evidence for the hy-

pothesis that fluency can arise from the interaction between perception and the motor system and that such fluency effects manifest themselves on the processing level, as a subjective fluency experience, and in the affective system.

Chapter 3

When Picking Sides Becomes Physical: How Affordances Drive Preferences

This chapter is based on:

Regenberg, N.F.E. & Semin, G.R. (2010). *When picking sides becomes physical: How affordances drive preferences*. Manuscript in preparation.

Abstract

In two experiments we hypothesized and showed that the situated constellation of bodily position and physical features of the environment create affordances that influence preference judgments. Participants imagined that they were to play table-tennis and had to pick a side. Participants playing with their right hand preferred the right side, whereas participants playing with their left hand preferred the left side. This occurred for participants' natural handedness (Experiment 1) and for a manipulation of the play-hand (Experiment 2). Our findings suggest that a) people use physical cues to make preference judgments, b) these cues differ as individuals differ in their physical makeup, and c) they are situated and emerge within the dynamics between the individual and the environment.

Imagine standing in a supermarket to buy the pasta for dinner. Will you prefer brand A or brand B? Will you be influenced by the fact that brand A is to your left on the shelf and brand B is to your right? And does it matter whether you are right- or left-handed? In the following, we argue with affordance theory (Gibson, 1979) that such spatial features shape our actions and preferences.

We define the affordance structure of a situation as the way our body morphology interacts with the physical constraints of the environment to determine the range of possible and likely actions (e.g., Gibson, 1979; Glenberg, 1997; Stoffregen, 2003). Consequently, because cognition is for action (Clark, 1997; Hommel et al., 2001; E. R. Smith & Semin, 2004), the meaning and the interpretation of a situation emerge from the situated constellation of the physical constraints of the environment and of one's own body. An obvious corollary from this assumption is that the affordances derived from a particular situation will depend on personal, physical characteristics, for example, being tall or short or being right- or left-handed. Whereas previous research has primarily investigated the immediate processing advantage that results from acting in line with such affordances (cf. Tucker & Ellis, 1998), we aim to show that the perception of action affordances also influences an individual's preferences, such that the most afforded, namely the least costly, course of action is preferred. We thus contribute to the existing research by demonstrating 1) the role of action affordances for making a preference choice and 2) the situatedness of this effect, namely that affordances arise from situational action capabilities.

An increasing amount of research suggests that when perceiving an object, we automatically think about our possibilities of interacting with this object. For instance, in an experiment (e.g., Tucker & Ellis, 1998), participants had to make judgments about whether graspable objects (e.g., a frying pan) were upright or inverted. To indicate their choice they had to use their right or their left hand to press a key. In addition to the invertedness dimension, the objects were displayed with a left- or rightward orientation. Responses were faster when they were made with

the hand for which it would be easier to grasp an object, even though this was actually irrelevant to the judgment. Experiments on language comprehension provide additional evidence: Individuals don't even need to *see* an object to think about corresponding actions (Borghetti, Glenberg, & Kaschak, 2004; Glenberg & Kaschak, 2002; Kaschak & Glenberg, 2000; Tucker & Ellis, 2004; Zwaan & Taylor, 2006). Overall, there is considerable evidence showing that upon the perception of a target object relevant actions are immediately potentiated. This is in line with the premise that cognition serves an adaptive function. Perception then needs to "*relate body and goals to the opportunities and costs of acting in the environment*" (Proffitt, 2006, p. 110). The fact that – upon entering a situation – the most afforded (i.e., least costly) actions are immediately potentiated should thus induce a *preference* for these actions over their less afforded alternatives. Therefore, we hypothesize that when individuals need to choose between two similar or seemingly equal alternatives, the emergence of an affordance structure will influence their preferences and the most afforded alternative is preferred.

Initial evidence suggests that preference judgments can be grounded in the motor system (Beilock & Holt, 2007; Bergh et al., 1990): Skilled typists repeatedly chose one of two letter dyads. The dyads were manipulated, such that typists would usually type the two letters with the same hand (e.g., FV) or with different hands (e.g., FJ). Skilled typists preferred different-hand letter dyads over same-hand letter dyads. The authors proposed that perceiving the letter dyads triggered the sensorimotor simulation of typing them. Simulating different-hand dyads was more afforded than simulating same-hand dyads, because the associated action of typing dyads with different hands is easier than typing dyads with the same hand. Moreover, the mere anticipation of motor fluency can drive preferences: Participants were asked to move one of two objects: the one they liked, disliked, or without an explicit instruction (neutral condition). The experimenters manipulated whether the objects were easy or difficult to grasp. In the neutral and like conditions, participants preferred the easy-to-grasp objects, whereas in the

dislike condition, participants had no clear preference (Ping, Dhillon, & Beilock, 2009).

If such preferences are truly embodied, affordance-based, and arise as the result of one's physical constraints in a situation, we propose that differences in a person's physical makeup should lead to systematically different preferences. Warren suggested that an individual's perception reflects his or her capabilities (1984). In his experiments, participants reported the height of stairs they could maximally climb or would prefer to climb. He found that what participants perceived as critical and preferred depended on their own leg length. Thus, participants took the dynamics between their bodies and the situation into account in their preference judgments. Similarly, Longo and Lourenco (2007) showed that participants' perception of near space is construed as a function of their arm length. The physical differences between participants have also been experimentally manipulated, for example by allowing for tool use. Witt, Proffitt, and Epstein (2005) manipulated whether participants reached for an object with their hands or with a baton and then assessed participants' perceived distance to the object. Participants thought the object was closer when it was easier to interact with (i.e., when reaching with a baton). In another experiment (Mark, 1987), participants made judgments about whether surfaces would afford sitting or climbing on. When wearing 10 cm high blocks under their feet, participants quickly adjusted their judgments to incorporate the additional 10 cm into their assessments of action capabilities. The perceived affordance structure thus changed as their bodily features changed.

Overall, these findings suggest that bodily differences and capabilities give rise to different perceptions of the same situation, namely to different action affordances. Indeed, in the above cited experiments with typists, the preference for the more afforded letter dyads only occurred for skilled typists, whereas novice typists showed no preference (Beilock & Holt, 2007). Thus, only when participants associated the dyads with meaningful motor patterns did the preference occur.

In the current experiments, we operationalized bodily differences with regard to the hand with which participants have to act. Most individuals have a clear preference for performing actions such as writing, pouring water into a glass, or playing table-tennis with their dominant hand. If the perception of a situation is action-based, as we propose, left- and right-handers should derive different affordances from the same situation. Moreover, when given a choice between an object that better affords a right-hand action vs. an object that better affords a left-hand action, such as reaching for a particular bag of pasta at the supermarket, an individual's preference should be driven by these affordances. Casasanto (2009) has introduced a similar argument as the body-specificity hypothesis: Assuming that mental representations are grounded in the motor system (cf. Barsalou, 1999; Prinz, 1997), individuals who differ in their physical make-up, for instance because they are right- vs. left-handed, should have different representations of manual actions. Indeed, in a series of experiments he showed that individuals associate positive valence with the side of their dominant hand, namely the side with which they can act more fluently. Willems, Hagoort, and Casasanto (2010) further demonstrated that for left- and right-handed individuals reading manual action verbs is associated with neural activity on the hemisphere that is respectively contralateral to their dominant hands.

In the current experiments, we extend the existing research in two ways. First, whereas previous research on the body-specificity hypothesis has focused on the general difference between right- and left-handers (Casasanto, 2009; R. M. Willems et al., 2010), we investigate the *situatedness* of this effect. For example, a right-handed individual might prefer the pasta on the right-hand shelf whereas a left-handed individual might prefer the pasta on the left, simply because it is more readily reachable. However, we propose that action affordances emerge as the product of situational constraints and one's own action capabilities: A right-handed individual who is holding tomatoes, cheese, and other sauce ingredients in her right hand, is likely to prefer the pasta on the left, as the situated constraints better afford a left-hand grasp. Second,

we extend the work on action affordances to the realm of choice preferences. Whereas previous research has shown that fluent interactions with objects lead to higher liking ratings for these objects (A. E. Hayes et al., 2008) and to positive affect (Cannon et al., 2010), we propose that the mere anticipation of such an interaction is sufficient to drive people’s preferences toward the most afforded alternative.

In sum, we hypothesized that the perception of action affordances in a situation will drive an individual’s preferences, such that the least costly action is preferred. Furthermore, in Experiment 1 we tested the hypothesis that action affordances are body-specific, namely those individuals with different action capabilities, such as being right- vs. left-handed, will form systematically different preferences. In Experiment 2, we investigated the situatedness of this effect, as we hypothesized that such action affordances are an emergent property of an individual’s general physical capabilities *and* the constraints of the situation.

3.1 Experiment 1: Handedness

We operationalized participants’ preferences as the choice between playing on the left vs. right side of a table-tennis table. Participants had to imagine that they were going to play table-tennis. They saw a drawing of a table-tennis table and had to pick a side to play on. We assumed that participants would simulate the situation in an embodied manner. This simulation should lead to an automatic potentiation of the most afforded action alternative. We expected that what is perceived as the most afforded action alternative would differ as a function of the participant’s handedness: For a right-handed person, the more afforded course of action should be to pick the right side of the table, as one can nearly reach that side by extending one’s arm whereas moving to the left side of the table requires a slightly more complicated action. For a left-handed person, the reverse should be true, such that the more afforded course of action should be to pick the left side of the table.



Figure 3.1: Stimulus material from experiments 1 and 2. Participants indicated on which side they preferred to play by clicking on one of the two avatars (Experiment 1) or by pressing a corresponding key (Experiment 2).

3.1.1 Method

Participants

Forty-two students participated in this study, but two were removed before the analyses, because they reported being ambidextrous. The final sample included 26 (self-reported) right-handed and 14 left-handed participants. Participants' handedness was assessed in an unrelated experiment.

Procedure

Participants imagined that they were to play table-tennis with their best friend and that they got to choose the side of the table to play at. Then were they asked: "On which side of the table-tennis table would you prefer to play?" Below the instructions we provided a schematic picture

of a table-tennis table. It was horizontally centered on the screen and viewed perpendicular to the long side of the table, in continuation of the net (see Figure 3.1). To the left and to the right of the table were identical stick-figures. Participants indicated where they preferred to play by clicking on one of the two figures.

3.1.2 Results and Discussion

The hypothesis that right-handed participants would prefer the right side of the table was supported in a binomial test (18 right side vs. 8 left side), $p < .05$, as was the hypothesis that left-handed participants would prefer the left side of the table (13 left side vs. 1 right side), $p < .001$. Overall, we expected the proportion of choices for the right side to be larger for right-handed than for left-handed individuals. A Fisher's exact test confirmed that this difference in proportions between left- and right-handers was significant, $p < .001$, with an odds ratio of 26.65 (95% *C.I.*[3.09 – 1299.15]). The likelihood of choosing the right side of the table was thus more than 26 times higher for right-handed participants than for left-handed participants. This strongly supports our hypothesis: To make a preference judgment about which side to play at, participants used the affordance structure of the situation, which emerged as a function of the physical constraints of the situation and their own bodies.

However, an alternative explanation is conceivable: Perhaps participants didn't derive their preference from the affordance structure, but have a general preference for the side of their dominant hand. Casasanto (2009), for example, showed that individuals associate the side of their dominant hand with positivity and the side of their non-dominant hand with negativity. Thus, participants might simply have learned this association, leading them to generally prefer the side of their dominant hand – irrespective of the situational affordance structure. On the contrary, we propose that an affordance structure is malleable and emerges in a situated manner (E. R. Smith & Semin, 2004). Thus, when there are no

other constraints, using the dominant hand is most afforded. However, when the dominant hand is blocked, because one is holding the pasta sauce ingredients, grabbing the bag of pasta with the non-dominant hand becomes the most afforded action. Similarly, instructing participants to play table-tennis with their non-dominant hand should also change their preference towards that side of the table-tennis table. In sum, we predict this to be the case because we assume that participants' preference choices are based on the affordance structure. If participants had a general preference for the side of their dominant hand, we should find a right-side preference for right-handed individuals, irrespective of whether they are going to play with their right hand or with their left hand.

3.2 Experiment 2: Situational Constraints

To address the question whether participants in Experiment 1 based their preferences on the perceived affordances, we experimentally manipulated the affordance structure in Experiment 2. We argued that bodily differences lead to the emergence of different affordances and that this happens in a situated manner. Thus, affordances arise as the result of the physical constraints *in a specific situation*. In many cases, these will coincide with previously established capabilities or habits: A right-handed individual will more likely use the right hand to put the key into the lock. However, when the default action isn't available because the situation imposes additional constraints, the affordance structure changes accordingly. Therefore, in this experiment, we used the same paradigm as in Experiment 1, but participants had to imagine playing with their dominant hand or their non-dominant hand.

Additionally, in Experiment 1, participants saw a drawing of the table-tennis table, but did not receive instructions about where to imagine themselves in the scene. To control for this, we included two position conditions in Experiment 2: a no-position-instruction condition to

replicate Experiment 1 and an explicit-position-instruction condition in which we told participants where to imagine themselves.

3.2.1 Method

Participants

Eighty-one students participated in the experiment and were randomly assigned to one of the four conditions in the 2 (dominant vs. non-dominant hand) x 2 (position instruction) design. We excluded five participants from the analyses, because they failed to report the correct play-hand after the experiment. Also, since we manipulated the affordance structure by instructing participants to play with their dominant or non-dominant hand, we only included the data of right-handed participants, excluding three left-handed participants.¹ The final sample included 73 participants (36 in the dominant hand condition).

Procedure

The table-tennis task was identical to Experiment 1 with three exceptions. First, participants were told that they and their friend were doing a skillfulness task and that they would play with their dominant (vs. non-dominant) hand. Participants' attention therefore wasn't explicitly directed at the right or left, but the play-hand instruction was disguised as a skillfulness task. We gave them a table-tennis racket to hold in their assigned play hand. Second, we controlled the position where participants imagined themselves in the scene. In the no-position-instruction

¹Although for logical reasons we only report the results for right-handed participants, the results remain the same when including the three left-handed participants. We would also expect this, as we assume the preferences to derive from the emerging affordance structure. Since we impose a play-hand, the preference choice should no longer differ between right- and left-handed individuals.

Play-hand	Position-Instruction	Choice for		Total
		left side	right side	
Right hand	No instruction	5	12	17
	Explicit instruction	5	14	19
	Total	10	26	36
Left hand	No instruction	13	5	18
	Explicit instruction	11	8	19
	Total	24	13	37

Table 3.1: Frequencies of choosing the left vs. right side of the table-tennis table as a function of participants’ play-hand and the position instruction in experiment 2

condition, participants saw the same drawing as in Experiment 1 without further instructions. In the explicit-position-instruction condition, the drawing contained an avatar symbolizing the participant’s position in front of the table-tennis table, facing the net, centered between the two sides. Third, participants indicated their preference for the side of the table-tennis table by pressing one of two neighboring keys on the keyboard instead of using the mouse since they held a racket in one hand. After participants had chosen a side, we assessed their actual handedness.

3.2.2 Results and Discussion

Participants imagined using their dominant or non-dominant hand. As we limit the analyses to right-handed participants, this is equivalent to playing with the right vs. left hand. We submitted the participants’ choice for the side of the table-tennis table to a 2 (play-hand) \times 2 (position instruction) logistic regression analysis. As expected, a main effect of the hand condition emerged, $Wald \chi^2 = 5.98$, $p < .05$, with an odds ratio of $Exp(B) = 6.24$ (95% *C.I.*[1.44 – 27.06]). There was no main or interaction effect of the position-instruction condition. For the subsequent analyses, we thus combined the two instruction conditions. Binomial tests revealed that participants playing with their right

hand were more likely to choose the right side of the table than the left, $p < .01$, and that participants playing with their left hand were more likely to choose the left side of the table than the right, $p < .05$. All frequencies are displayed in Table 3.1. Overall, participants' preference choice differed as a function of their play-hand. This effect was symmetrical and occurred for participants imagining to play with their right hand and with their left hand.

3.3 General Discussion

Two experiments showed that individuals use the affordance structure of a situation to derive preferences. Experiment 1 demonstrated that people use cues from their bodies and that these cues differ as a function of bodily differences: Left- and right-handers had systematically different preferences for playing at the left vs. at the right side of a table-tennis table respectively. Experiment 2 revealed that this effect depended on a situated construal of the affordance structure: The preference of right-handers changed toward the left side when they imagined playing with their left hand compared to their right hand.

We argue that the physical affordances an actor derives from a situation are a situated, emergent property of the dynamics between the actor and the environment, which lead to an action-driven perception of the situation. This is consistent with theories of embodied cognition (cf. Barsalou, 1999; Glenberg, 1997). Our results show that this link between perception and action possibilities not only results in a processing advantage of afforded actions (e.g., Tucker & Ellis, 1998, 2004), but it can also drive people's preferences towards the most afforded alternative.

It is noteworthy that participants in our experiments made a choice about which side of the table-tennis table they wanted to *play on* – not where they preferred *to go*. Since both sides were actually equally likely

and participants were explicitly instructed to think about where to play, we propose that the mere anticipation of how easily they could move toward either side of the table was sufficient to influence their preferences. Although our experiments do not address this mediating process directly, we suggest that our results are driven by the perceived fluency that the participants anticipate for each course of action. Indeed, in a recent set of experiments, we showed that acting in line with perceived affordances triggers positive affect and a feeling of processing fluency (Regenberg, Häfner, & Semin, in press). This corroborates research by Hayes et al. (2008), in which participants grasped objects and moved them around. This movement was manipulated to be either fluent or involved avoiding an obstacle and was therefore disfluent. Participants then rated how much they liked the object compared to other objects of its kind. As expected, participants liked the objects more after a fluent movement than after a disfluent movement. This suggests that fluent interactions lead to more preferable evaluations. Our current findings add to this by demonstrating that the mere anticipation of such an interaction (“Should I go to the left or to the right?”) is enough to drive people’s preferences. Similarly, Nisbett and Wilson (1977) already showed a position effect on the evaluation of consumer products. In an array of identical stockings, the right-most stocking was often preferred. The current work might offer an affordance-based account of this effect. Assuming that almost 90% of a normal population is right-handed (cf. Gilbert & Wysocki, 1992), the position bias could indicate that participants chose the stocking that they could most easily interact with, the one on their dominant side.

Our results furthermore support the body-specificity hypothesis (Casasanto, 2009). Experiment 1 shows that preference judgments are body-specific. Participants prefer the affordance-based fluency over less fluent actions. In Experiment 2 we demonstrate that the proposed body-specificity is malleable and situation-dependent. Therefore, we propose that the experience of motor fluency and its effects on preference choices and evaluations (cf. A. E. Hayes et al., 2008) is an emergent phenomenon. Individuals can easily adapt their capabilities to tools or

other changes in their bodily capabilities (Longo & Lourenco, 2007; Witt et al., 2005; Warren, 1984). Overall, our findings encourage the use of an embodied, situated approach to cognition, where the individual is treated as an actor in a dynamic system of him- or herself and the environment.

Chapter 4

Getting in Touch With Your Senses: Costs and Benefits of Multimodal Processing

This chapter is based on:

Regenberg, N.F.E., Häfner, M., & Semin, G.R. (2010). *Getting in touch with your senses: The costs and benefits of multimodal processing*. Manuscript in preparation.

Abstract

According to the theory of perceptual symbol systems (Barsalou, 1999), concept representations are modality-specific and context-dependent. Previous research has shown that therefore switching between modalities when processing concept words incurs a cost. In the present research, we propose that encoding concepts within a multi-modality context enriches their mental representation, such that it is easier to derive the concept's meaning. In Experiment 1, we show that despite the processing cost associated with modality-switching, participants report more positive mood after processing a multi-modality context than after a single-modality context. Furthermore, concepts encoded with properties from several modalities became more accessible and participants liked them more than concepts encoded with properties from a single modality (Experiment 2). Our findings are in line with situated, embodied accounts of cognition, which assume concept representations to be dynamic and provide experimental evidence that this representational flexibility can have implications for an individual's processing experience per se.

Think about an eggplant and whether it *looks purple, dark, and shiny*. What kind of mental representation do you now have for the concept EGGPLANT? Now think again about an eggplant and whether it *feels smooth, looks dark, and tastes bitter*. Does this description evoke a different representation of the concept EGGPLANT than the first description? Prior research from an embodied cognition perspective (cf. Barsalou, 1999) suggests that conceptual representations are based on sensorimotor simulations and that therefore processing concepts with properties from different sensory modalities, such as touch, vision, and taste, incurs a cost compared to processing concepts with properties from the same modality (Pecher et al., 2004). In the present experiments, we explore the consequences of encoding concepts in a single-modality context (e.g., visual) vs. in a multi-modality context (e.g., tactile, visual, and gustatory) for their representation. We propose that although such concept-property pairs are initially more easily processed in a single-modality context (Pecher et al., 2003, 2004), concepts encoded within a multi-modality context gain a richer semantic representation. We expect that such semantic richness makes concepts more accessible and evokes a positive affective response.

4.1 Modality-Specific Processing and Semantic Richness

Semantic richness refers to the amount of information (the number of features and associations) individuals generate when thinking about the meaning of a concept (Pexman, Hargreaves, Edwards, Henry, & Goodyear, 2007). Words with a rich semantic representation are more readily accessible in the mind, that is, they are processed faster than words with a poorer semantic representation. For example, the number-of-features effect holds that words associated with a high number of features are responded to faster during lexical decisions (Grondin, Lupker, & McRae, 2009; Pexman, Lupker, & Hino, 2002). Previous research has typically treated semantic richness as a general trait of concept words

by using word norms (cf. McRae, Cree, Seidenberg, & McNorgan, 2005; D. L. Nelson, McEvoy, & Schreiber, 2004) to create a controlled set of stimuli which, for instance, vary only on the number-of-features dimension (e.g., Grondin et al., 2009; Kounios et al., 2009; Pexman et al., 2002; Pexman, Holyk, & Monfils, 2003). In the current research, on the other hand, we address the malleability of concept representations and its consequences for one's *processing experience*. We employ a situated cognition approach (cf. E. R. Smith & Semin, 2004) to conceptual thought assuming that cognition serves action and is hence dynamic and situation-specific (Barsalou, 2003; Yeh & Barsalou, 2006; Zwaan et al., 2004). Therefore, concept representations should be contingent on the current processing context. Particularly, we propose that the semantic richness of a concept's current representation is variable and can be influenced by the context in which it is encountered.

The present work is based on recent theories suggesting that sensorimotor simulations underlie conceptual representations (e.g., Barsalou, 1999, 2008; Glenberg, 1997). According to the theory of perceptual symbol systems (PSS, Barsalou, 1999), concepts are represented by simulations of actual experiences with those concepts. Thus, for example, thinking about the concept EGGPLANT could involve the neural systems for vision, touch, taste, and action to re-enact experiences with an eggplant. Importantly, the theory assumes that such perceptual simulations are dynamic and context-dependent. Someone who is about to cut and fry an eggplant is likely to have a different representation of it than someone who is about to throw it to someone else. An increasing amount of research supports the hypothesis that such dynamic, context-dependent simulations underlie conceptual thought (e.g., Barsalou, 1983; Zwaan, Stanfield, & Yaxley, 2002; see Yeh & Barsalou, 2006 for more examples). For instance, participants read sentences about an object in different locations, which implied a particular shape of the object, such as an egg in a refrigerator vs. an egg in a skillet (Zwaan et al., 2002). They then saw a line drawing of that object and indicated whether or not it had been mentioned in the sentence. Participants' responses were facilitated when the object's shape in the drawing

matched the shape implied by the preceding sentence supporting the hypothesis that conceptual thought, including language comprehension, involves perceptual symbols that are dynamically adapted to the current context (see also Borghi et al., 2004; Glenberg & Kaschak, 2002; Zwaan et al., 2004).

Moreover, PSS theory proposes that conceptual representations are a partial re-enactment of actual experiences and that therefore the resulting simulations are modality-specific. Thinking about whether an eggplant is purple will thus evoke a different representation of the concept EGGPLANT than thinking about whether it tastes bitter. Evidence for the modality-specificity of simulations comes from experiments employing a property-verification task. Participants verified whether a property is typically true of a given concept (Pecher et al., 2003), e.g., the property *loud* for the concept BLENDER. The preceding trial always involved a different concept-property pair with a property from the same sensory modality (e.g., LEAVES-*Rustling*) or with a property from a different sensory modality (e.g., CRANBERRIES-*tart*). Participants were faster when the modality mentioned in the preceding sentence was the same as in the current sentence. This finding suggests that language comprehension is modality-specific, such that switching from one modality to another incurs a processing cost similar to that observed when processing perceptual signals from different modalities (Spence, Nicholls, & Driver, 2000). In a similar paradigm, Pecher et al. (2004) presented concept words twice with several intervening trials. They varied whether the concept (e.g., APPLE) was paired with two properties from the same modality (e.g., *green*, *shiny*) or with two properties from different modalities (e.g., *tart*, *shiny*) on the two occurrences. On the second occurrence of each concept, participants responded faster and more accurately when the properties came from the same modality than when they came from different modalities. This happened even after a lag of several intervening trials, such that there seem to be concept-specific long-term consequences driven by the componential and dynamic nature of ongoing simulations.

In other words, such contextualized simulations of the same concept might not only differ in the sensory modalities they involve, but they can also vary in the extent to which different sensory modalities are involved: Thinking of an eggplant with the goal to throw it might involve mainly tactile properties, whereas thinking about how to cut and fry an eggplant might involve both tactile and gustatory properties. We propose that the contextualized, modality-specific mechanism underlying conceptual thought fundamentally affects the current representation of a concept, above and beyond the demonstrated processing advantage for properties from the same modality (Pecher et al., 2003, 2004; Van Dantzig et al., 2008; Vermeulen, Corneille, & Niedenthal, 2008). Whereas the immediate processing might be more costly when one needs to switch between modalities, the activation of several sensory modalities when processing a particular concept – as compared to just one modality – and thus the association of multi-modality properties with that concept may lead to a richer semantic representation. A concept may become more easily imaginable (i.e., more accessible) the more modalities are involved in its representation. In other words, the more modalities are involved in a concept’s representation the more accessible its meaning should become: In real-life, we often don’t only have one sense to rely on, but at the same time, we know how something looks, smells, and feels. In line with this observation, a recent experimental finding implicates that individuals recognize visual stimuli faster when they are accompanied by a semantically-congruent sound (Chen & Spence, 2010).

In sum, we hypothesize that the more sensory modalities are involved in the representation of a concept, the richer the concept’s representation becomes and thus the concept’s meaning becomes more easily accessible. Importantly, unlike previous research on semantic richness effects (e.g., Grondin et al., 2009; Kounios et al., 2009; Pexman et al., 2002, 2003), we assume that concept representations are not static, but that the current representation of a concept is construed according to recent experiences with it (cf. McClelland & Rumelhart, 1985; E. R. Smith, 1996). Thus, we predict that processing a concept within a multi-modality context increases the semantic richness of its current representation as compared

to processing it within a single-modality context even though the latter representation might be created more easily (Pecher et al., 2003, 2004).

4.2 Representational Richness and Processing Fluency

Ultimately, we propose that this representational richness influences an individual's processing experience. Research on fluency suggests that representational richness facilitates the ease with which information can be processed or retrieved (Gill et al., 1998). For example, increasing the number of well-integrated facts associated with a concept increases its retrieval fluency, indicated by the speed with which that information can be recalled (Myers et al., 1984; E. E. Smith et al., 1978). Moreover Gill et al. (1998) demonstrated that representational richness not only produces fluency but that this in turn affects the confidence individuals have in their judgments. The hedonic marking hypothesis of fluency (Winkielman et al., 2003) proposes that fluency experiences are generally associated with positive affect and enhance liking for the targets of processing. For example, conceptual fluency can increase evaluative judgments (Whittlesea, 1993, Experiment 5): Participants liked target words better when they were presented in a predictive semantic context (e.g., "The stormy seas tossed the BOAT.") than when they were presented in a non-predictive context (e.g., "He saved up his money and bought a BOAT.").

Therefore, we hypothesized that if processing concepts in a multi-modality context increases the richness of their semantic representation as compared to when they are processed in a context involving just one sensory modality, then these concepts should become associated with a positive affective response. Specifically, we tested the hypotheses that a multi-modality context leads to a richer semantic representation and thus triggers implicit positive affect and that concept words associated with properties from different modalities are more accessible and are

evaluated more positively than concepts associated with properties from one modality.

4.3 Overview of the Current Research

We propose that although switching between sensory modalities while processing concept words produces a cost (Pecher et al., 2003, 2004), such multi-modality processing increases the richness of the concept's representations. As representational richness is known to increase accessibility (Grondin et al., 2009; Pexman et al., 2002) and to foster processing fluency (cf. Gill et al., 1998), we hypothesized that processing concepts within a multi-modality context ultimately produces a positive affective response. Experiment 1 tested this hypothesis. Furthermore, concepts associated with properties from different modalities should become more accessible than concepts associated with properties from one modality and should be evaluated more positively. We addressed these hypotheses in Experiment 2. In both experiments, we used a property-verification task paradigm.

4.4 Experiment 1: Multi-Modality Contexts Produce Positive Affect

We assumed that processing concept words in a multi-modality context increases representational richness as compared to processing concept words in a single-modality context. In this experiment, we investigated whether this results in the experience of positive affect after processing a multi-modality context as compared to processing a single-modality context. We administered a property verification task similar to that used by Pecher et al. (2003), but presented the concept-property pairs in sequences which were manipulated to involve a mix of different modality-properties or all properties came from the same modality. After each

sequence, participants rated the pleasantness of a Chinese ideograph, a measure known to capture implicit affect (Murphy & Zajonc, 1993). We expected to replicate the typical switching cost effect on participants' response latencies while processing the concept-property pairs: They should be faster on single-modality sequences than on multi-modality sequences. However, we hypothesized that despite these switching costs, participants would experience more positive affect after multi-modality sequences as indicated by higher pleasantness ratings of the Chinese ideographs as a result of the representational richness produced by the multi-modality context.

4.4.1 Method

Participants

Seventy students participated in the experiment for a small monetary reward or course credit. We excluded four participants before the analyses, because they answered less than 70% of the property-verification trials correctly, and an additional two participants because Dutch (the language the experiment was conducted in) was not their native language.

Design

Participants always saw sequences of eight trials of the property-verification task and then judged the pleasantness of a Chinese ideograph. We manipulated the property-verification task sequences to form a multi-modality context involving properties from four different sensory modalities: vision, audition, touch, and smell or taste or a single-modality context in which all trials involved the same modality (vision, audition, or touch). Participants did 24 such sequences, i.e., a total of 24 ideograph evaluations and 192 property verification task trials. They could

take a break after twelve sequences (six multi- and six single-modality sequences).

Materials

The stimulus set included 32 sentences of concept-property pairs, from each of the three modalities vision, audition, and touch, e.g., “A cave is chilly.” These sentences were partially taken from van Dantzig et al. (2008) and amended by additional concept-property pairs from each modality. Furthermore, in order to have sentences from four different modalities for the multi-modality sequences, we added concept-property pairs from taste and smell. The properties from all sentences were paired with new concepts to create an equal number of false filler sentences. We placed all sentences in two lists, such that the same properties (once paired with a concept to form a TRUE sentence and once to form a FALSE sentence) never appeared in the same experimental block (each comprised of twelve such sequences after which participants could take a break), except for some tactile properties because the tactile modality has fewer property words than the other modalities (cf. Pecher et al., 2003). The order in which participants saw these two stimulus lists was counterbalanced across participants. The order of presentation and whether a sentence appeared in a multi- or single-modality sequence was randomized within each list and across participants. The materials can be found in Appendix A.

Procedure

We told participants that they were participating in language research and that they would do a reaction time task in which they had to verify properties for concrete object words. Furthermore, we told them that they would sometimes have to do a different task in between to make the experiment more exciting: the pleasantness ratings of the Chi-

nese ideographs. Participants always did a sequence of eight property verification task trials and then evaluated a Chinese ideograph. The ideographs were randomly chosen without replacement from a pool of ideographs. To familiarize participants with the task, they did four practice sequences at the beginning of the experiment with sentences and concepts that did not reappear during the experiment, each followed by a Chinese ideograph evaluation.

Within each sequence, four responses required a TRUE response and four were FALSE. In single-modality sequences, all trials included properties from one particular modality (vision, audition, or touch). In multi-modality sequences, the four properties for the true trials came from four different modalities (vision, audition, touch, and smell or taste) and the properties for the false trials came from the same four modalities. Each property-verification trial started with a warning signal (*****) presented for 500 ms at the center of the screen, then the sentence appeared in the same position. It remained on the screen until participants made a response (TRUE or FALSE) by pressing a button with the left or right hand or until 3000 ms had elapsed. Whether participants made the true response with the right or left hand was counterbalanced across participants. Then the next sentence appeared. After the eighth trial within each sequence, the warning signal consisted of a blue square of asterisks, which was presented for 500 ms. Participants then knew to expect a Chinese ideograph, which appeared for 100 ms and was pattern masked for 100 ms. Next, participants were asked how pleasant or unpleasant they thought the ideograph had looked on a scale from 1-6. The scale was displayed vertically to avoid confusion with the response hands and participants responded by typing in the corresponding number. Participants then saw an instruction for 3000 ms to get ready again for the reaction time task, and after a blank of 500 ms, the next sequence of property verification task trials began.

4.4.2 Results

Response latencies and accuracy

We analyzed only sentences requiring a “true” response and only when they were answered correctly. Furthermore, as commonly the case with reaction times (Ratcliff, 1993, see also Bargh & Chartrand, 2000), the distribution was positively skewed. We therefore removed reaction times that were faster than 300 ms or more than two standard deviations above the respective condition mean and conducted a repeated measures analysis of variance (ANOVA) with the condition the sentence appeared in (multi- vs. single-modality context) to assess the typical switching cost effect. As expected, participants were faster on single-modality trials ($M = 1215.41$, $SD = 168.75$) than on multi-modality trials ($M = 1259.40$, $SD = 177.98$), $F(1, 63) = 28.67$, $p < .001$, $\eta_p^2 = .31$. A parallel analysis of participants’ accuracy rates yielded no effect, $F(1, 63) = 1.18$, $p = .281$, $\eta_p^2 = .02$ ($M_{single} = .87$, $SD = .06$; $M_{multi} = .87$, $SD = .05$), rendering a speed-accuracy trade-off unlikely (cf. Pecher et al., 2003).

Implicit affect

We analyzed the pleasantness ratings of the Chinese ideographs in a repeated measures ANOVA assessing the effect of the type of sequence (multi- vs. single-modality). As predicted, participants gave higher pleasantness ratings after multi-modality sequences ($M = 3.16$, $SD = 0.87$) than after single-modality sequences ($M = 3.05$, $SD = 0.86$), $F(1, 63) = 4.68$, $p = .034$, $\eta_p^2 = .07$.

Although we did not find an effect of the modality-type on participants’ accuracy during the property-verification task, it is possible that participants’ perception of how accurately they were performing influenced these pleasantness ratings nevertheless. In order to control for this possible confound, we used a multi-level approach for the repeated

measures design to assess the effect of the modality condition on the ideograph evaluations, while controlling for participants' accuracy during each sequence using the generalized linear equations module in SPSS 15. It supported the previous analysis and yielded the hypothesized effect of the modality condition, $Wald \chi^2(df = 1) = 4.98, p = .026$, but no effect of participants' accuracy, $Wald \chi^2(df = 1) = 1.60, p = .205$.

4.4.3 Discussion

In this experiment, we replicated the effect that switching between modalities when processing concept words incurs a cost (Pecher et al., 2003). Moreover, we demonstrated that albeit this cost, participants' gave higher pleasantness ratings for Chinese ideographs after multi-modality sequences than after single-modality sequences. We propose that representational richness underlies this effect because a multi-modality context should foster a richer semantic representation than a single-modality context. However, the design of this experiment does not allow for any conclusions regarding the underlying mechanism. We addressed this in the second experiment.

4.5 Experiment 2: Concept Accessibility and Liking

In Experiment 2, we directly tested the hypothesis that concepts processed with properties from different modalities gain a richer semantic representation than concepts processed with properties from one single modality. Furthermore, we hypothesized that this representational richness influences an individual's evaluation of a concept word. Particularly, we propose that concepts associated with properties from several modalities are more accessible and are evaluated more positively than concepts associated with properties from just one modality.

We presented concept words repeatedly in a property verification task, always paired with a new property. We manipulated whether these properties for one concept came from the same modality or from different modalities. This design is similar to that of Pecher et al. (2004), who have demonstrated a switching cost effect during processing: Responses to concept-property pairs involving the same modality as on a previous occurrence of the concept were facilitated as compared to concept-property pairs involving a modality that had not been presented with this concept. However, we were interested in the consequences this has for the representation of these concepts. Thus, after administering the property verification task, we assessed the accessibility of these concepts with a lexical decision task. Subsequently, participants gave an evaluation rating for each of the concept words. We hypothesized that the semantic richness produced by processing concepts with properties from different modalities would increase their accessibility, as indicated by faster recognition latencies on the lexical decision task, and participants' explicit evaluation of them.

Furthermore, we sought to explore the dynamics and limitations of this effect. In addition to the modality condition, we manipulated whether each concept-property pair appeared once or four times during the property verification task. Repeated exposure to stimuli is known to evoke a more positive evaluation (Zajonc, 1968, for a review see Bornstein, 1989). Thus, this exposure condition serves as reference to which to compare the increase we expect in the concept evaluations for multi-modality concepts as compared to single-modality concepts: In general, repeated exposure should lead to a more favorable evaluation of the concept words. Thus, examining the effect of the modality condition on the concept evaluations against this exposure background provides information about where the predicted effect lies. We predicted that the semantic richness associated with multi-modality concepts would increase participants' evaluation of the concept words. Therefore, this should become particularly visible in the single-exposure condition, because in the repeated-exposures condition the evaluations should gen-

erally increase, which is likely to produce a ceiling effect thereby eliminating the advantage of multi-modality concepts.

In sum, we thus predicted that concepts that are paired with properties from different modalities during the property verification task gain a richer semantic representation. Therefore, they should be more accessible during a lexical decision task and they should be evaluated more positively. We expect this effect to be modulated by the exposure condition of the concepts, such that multi-modality concepts are evaluated more positively than single-modality concepts in the single-exposure condition, but that this difference is attenuated after repeated exposures, because these should also elevate the evaluations of concepts in the single-modality condition.

4.5.1 Method

Participants

Forty-seven students participated in the experiment. We excluded two participants before the analyses, because Dutch (the language the experiment was conducted in) was not their native language. Furthermore, we omitted the data of five participants whose accuracy rate on the property verification task or the lexical decision task was below 70%. Finally, we excluded three additional participants, because they did not properly participate as they responded with the same value to all rating scales involved in the experiment. The final sample thus included thirty-seven participants.

Materials and design

All stimuli were concrete concept words. Each concept was paired with three different properties during the property verification task. Depend-

		Modality Condition	
		single	multi
Exposure	single	3 concepts \times 3 properties from one modality \times 1 exposure = 9 trials	3 concepts \times 3 properties from different modalities \times 1 exposure = 9 trials
	repeated	3 concepts \times 3 properties from 1 modality \times 4 exposures = 36 trials	3 concepts \times 3 properties from different modalities \times 4 exposures = 36 trials

Table 4.1: Design overview of experiment 2

ing on the modality condition, these properties all came from the same modality (e.g., EGGPLANT – *purple, dark, shiny*) or all came from different modalities (e.g., EGGPLANT – *purple, smooth, eatable*). Importantly, across participants, each concept appeared about equally often in the same- and multi-modality condition. Furthermore, depending on the exposure condition, these concept-property pairs were either presented once each or four times each during the property verification task. Within each cell of this 2 (modality condition) \times 2 (repetition condition) design, we presented three different concepts, leading to a total of 90 target trials (see Table 4.1 for design overview). These were matched with 90 false filler trials.

To select the concept-property pairs, we conducted pilot studies to assess the pair’s valence and the typicality of the property for the concept. Both valence and typicality were assessed on a 6 point scale ranging from -3 (negative / not typical) to +3 (positive / typical). Pairs were only included if they had a positive typicality value (i.e., they were seen as more typical than atypical) and if they were as neutral as possible with regards to valence (i.e., close to 0). The complete stimulus materials are given in Appendix B.

We created twelve lists of stimulus combinations that fulfilled the following criteria: First, the three concepts in the single-modality conditions each involve a different modality (e.g., EGGPLANT – three visual properties, DISH TOWL – three actions, LIGHT BULB – three tactile properties). Second, the mean valence and typicality ratings do not significantly differ between the four conditions, ensuring that valence and typicality were held constant within participants. Third, all concepts appear about equally often in each condition across participants. Within these twelve combinations, the order of the stimuli was pseudo-randomized per participant with the restrictions that the same concept could never appear twice in a row and that no more than four true or four false trials appeared in a row.

Procedure

Participants first did the property verification task, which followed the same procedure as in Experiment 1, although without the Chinese ideograph evaluations. Participants could then take a break and proceed to the lexical decision task on their own. They were told that the task tested their ability to focus and that they had to indicate as quickly and accurately as possible whether a presented word was an existing Dutch word by pressing one of two keys. During the lexical decision task, participants saw the twelve target concepts and four additional fillers. These 16 concepts were matched with 16 non-words, which were created with the same letters as the target concepts and also started with the same initial letters. Each trial started with a fixation cross presented at the center of the screen for 300 ms, followed by a blank for 200 ms and the target concept, which remained on the screen until participants gave a response. Participants first did six practice trials with unrelated words and then saw three consecutive blocks of the 32 trials (16 concepts and 16 non-words) without a break in between. The presentation order was randomized per participant and block with the restriction that no more than four words or four non-words could appear in a row.

After the lexical decision task, participants could again take a break and then proceeded to the concept evaluations. They were reminded that they had verified properties for concept words at the beginning of the experiment and were told that we wanted to assess how positive or negative these concept words were for them in order to better understand our results. We instructed participants that there were no right or wrong answers and that they shouldn't think too long about each answer, but should answer spontaneously and intuitively. Then the twelve target concepts appeared one after another in a random order with a 6-point rating scale (ends labeled "negative" and "positive") with the sentence "I find <concept>..." displayed above the scale.

Modality Condition	Exposure Condition	RT		ACC	
		M(SD)	N	M(SD)	N
multi-modality	single	1142.64 (209.21)	36	.62 (0.23)	37
	repeated	897.99 (116.34)	36	.80 (0.16)	37
single-modality	single	1067.53 (194.46)	36	.70 (0.20)	37
	repeated	896.75 (105.07)	36	.85 (0.11)	37

Table 4.2: Mean reaction times (RT, in milliseconds) and accuracy rates (ACC, percentage) during the property verification task in experiment 2 as a function of the modality and exposure conditions

4.5.2 Results

Property verification task

We analyzed response latencies on true trials of the property verification task if the trial was answered correctly and the latency was slower than 300 ms and faster than 2 SD of the respective condition mean. We submitted these and the participants' accuracy rates to 2 (modality condition) \times 2 (exposure condition) repeated measures ANOVAs. For the response latencies, the analysis yielded the expected effect of the modality condition, $F(1, 35)^1 = 5.65$, $p = .023$, $\eta_p^2 = .14$, an effect of the exposure condition, $F(1, 35) = 105.42$, $p < .01$, $\eta_p^2 = .75$, and an interaction effect between modality and exposure, $F(1, 35) = 4.48$, $p = .042$, $\eta_p^2 = .11$. As the means in Table 4.2 indicate, participants were faster on trials with single-modality concepts than on trials with multi-modality concepts. Not surprisingly, participants were also faster on concept-property pairs that re-occurred than that appeared only once. The interaction effect further shows that the processing advantage of single-modality concepts over multi-modality concepts existed when each concept-property pair was shown once, $F(1, 35) = 6.06$, $p = .019$, $\eta_p^2 = .15$, but was attenuated when participants saw each concept-property pair four times, $F(1, 35) < 1$.

¹Degrees of freedom vary due to an empty cell for one participant after removing outliers from the reaction time data.

Similarly, the analysis of participants' accuracy rates yielded the predicted main effect of the modality condition, $F(1, 36) = 9.01$, $p = .005$, $\eta_p^2 = .20$ and a main effect of the exposure condition, $F(1, 36) = 38.36$, $p < .001$, $\eta_p^2 = .52$, but no interaction, $F(1, 36) < 1$: Participants were more accurate on trials with single-modality concepts than on trials with multi-modality concepts and they were more accurate on concept-property pairs that appeared repeatedly (see Table 4.2).

Lexical decision task

Again we only analyzed latencies on correctly answered trials and if the response fell within a 300 ms to 2 *SD* interval of the respective condition mean. We hypothesized that concepts paired with properties from different modalities gain a richer semantic representation. Therefore, these concepts should be recognized faster during lexical decisions. However, despite the fact that we have carefully piloted and selected the stimulus materials based on valence and typicality, it is possible that the target concepts differ in their natural accessibility. Therefore, we employed a multi-level approach to our repeated measures design, including the modality and exposure conditions, the different concept words, the specific list of stimulus combinations a participant saw, and all their interaction terms as factors. Furthermore, during the property verification task, participants were more accurate on single-modality concepts than on multi-modality concepts. To control for the possibility that the concept accessibility is driven by participants' (in)accuracy, we used each participants' accuracy score for each concept as a covariate.

The analysis yielded the predicted main effect of the modality condition, $Wald \chi^2(df = 1) = 5.60$, $p = .018$. Participants recognized multi-modality concepts faster than single-modality concepts (see Table 4.3). The analysis further revealed a main effect of the exposure condition, $Wald \chi^2(df = 1) = 3.91$, $p = .048$, indicating that participants recognized repeated concepts faster. Interestingly, the analysis also yielded an interaction between the modality and exposure condi-

Modality Condition	Exposure Condition	LDT: RT		Evaluations	
		M(SD)	N	M(SD)	N
multi- modality	single	548.37 (94.48)	37	4.43 (1.76)	37
	repeated	531.89 (79.53)	37	4.47 (1.74)	37
single- modality	single	550.33 (80.27)	37	4.27 (1.76)	37
	repeated	551.65 (84.23)	37	4.56 (1.70)	37

Table 4.3: Mean reaction times during the lexical decision task (LDT: RT, in milliseconds) and explicit concept evaluations in experiment 2 as a function of the modality and exposure conditions

tions, $Wald \chi^2(df = 1) = 4.56, p = .033$: The expected and observed accessibility advantage of multi-modality concepts over single-modality concepts was enhanced by repeated exposures, $Wald \chi^2(df = 1) = 12.94, p < .001$, but not evident for single-exposure concepts, $Wald \chi^2(df = 1) < 1, p = .730$ (see Table 4.3).²

Concept evaluations

We predicted that the representational richness experienced with concepts associated with multi-modality properties influences the participants' evaluation of these concept words. Specifically, we hypothesized that multi-modality concepts are evaluated as more positive than single-modality concepts, but that this difference should be attenuated through repeated exposures to the concepts. Given the same logic as for the analyses of the lexical decision task, we used a multi-level analysis including the modality and exposure conditions, the different concept words, the specific list a participant saw, and all their interaction terms as factors, and participants' accuracy rate for each concept

²The analysis further showed main and interaction effects of the particular concept words. However, these are not of theoretical interest to the current experiments and we will therefore not discuss them.

as a covariate. Of the effects of interest,³ the analysis only yielded the expected interaction between the modality and exposure conditions, $Wald \chi^2(df = 1) = 4.62, p = .032$, indicating that participants liked multi- and single-modality concepts equally after repeated exposures, $Wald \chi^2(df = 1) = .05, p = .827$, but they tended to like multi-modality concepts more than single-modality concepts in the single-exposure condition, $Wald \chi^2(df = 1) = 2.27, p = .099$ (see means in Table 4.3).

4.5.3 Discussion

In line with previous experiments (Pecher et al., 2004), participants verified properties for concepts faster if the different properties involved only a single modality than if they involved multiple modalities. However, we demonstrated that concepts associated with multi-modality properties became subsequently more accessible, as indexed by a lexical decision task, and were evaluated as more positive than the concepts paired with single-modality properties. We propose that the semantic richness of the representations underlies these findings, such that multi-modality processing increases a concept's representational richness. Furthermore, as predicted, repeated exposure to a concept attenuated the effect on the explicit concept evaluations: Whereas concepts in the multi-modality condition were evaluated as relatively positive even after only one exposure per concept-property pair, single-modality concepts only became positive after repeated exposures.

Interestingly, the manipulation of modality and exposure also interacted in determining the concept's accessibility. Participants were faster at recognizing multi-modality concepts than single-modality concepts, but this was particularly the case if the concept-property pairs were presented repeatedly. Our results might therefore suggest that represen-

³The analysis further showed main and interaction effects of the particular concept words. However, these are not of theoretical interest to the current experiments and we will therefore not discuss them.

tational richness influences processes differently depending on whether they take place outside of an individual's awareness, as in the case of the lexical decision task, or whether they are contingent on explicit evaluation processes. Whereas the accessibility difference between multi- and single-modality properties was increased upon repeated exposures, the evaluation difference was attenuated upon repeated exposures.

4.6 General Discussion

The current experiments provide evidence that although processing concepts within a multi-modality context produces switching costs, the resulting processing experience is positive and yields a higher accessibility and more positive evaluation for the respective concepts. Specifically, in Experiment 1, we demonstrated that although participants are slower at verifying sequences of concept-property pairs from different modalities than sequences of pairs from one single modality, they experience more positive affect after multi-modality contexts, as indicated by higher pleasantness ratings of Chinese ideographs. We thus replicated previous experiments investigating the costs of processing multi-modality stimuli (Pecher et al., 2003, 2004; Van Dantzig et al., 2008; Vermeulen et al., 2008), but showed that such processing experiences can have affective consequences. We proposed that the underlying mechanism is the current representational richness of these concepts and tested this in Experiment 2 by manipulating whether a concept was paired with properties from different modalities or with properties from just one modality. Again, we replicated the switching cost: Participants verified concept-property pairs faster if all properties involved the same modality (cf. Pecher et al., 2004), but showed that multi-modality concepts became subsequently more accessible and were evaluated more positively than single-modality concepts.

We suggest that our findings corroborate the idea that concept representations are not static, but are instead construed in a dynamic and

contextualized manner (cf. E. R. Smith, 1996; E. R. Smith & DeCoster, 1998), taking into account, for example, recent experiences with the concept. Our results are therefore consistent with theories of situated cognition (cf. E. R. Smith & Semin, 2004), supporting the proposal that the human conceptual system is embodied and situated (Barsalou, 1999, 2003; Glenberg, 1997; Glenberg et al., 2009; Yeh & Barsalou, 2006; Zwaan et al., 2004). Moreover, while embodied theories of cognition propose that it is necessary to *ground* cognition in modality-specific systems in order to grasp the meaning of something (cf. Harnad, 1990; Searle, 1980; see also Glenberg & Robertson, 2000), the current experiments show that representations become richer the more modalities they incorporate, facilitating the construction of meaning. In other words, we propose that the more modalities are involved in a representation, the more meaningful it becomes. Importantly, however, although the focus of the present work has been on the flexibility and situatedness of human cognition, we do not assume that conceptualizations are *only* situationally driven. While there is variability in concept representations (e.g., Barsalou, 1993) intra-individual stability can be achieved by assuming that particular aspects and properties of a concept have been repeatedly construed, thus forming a default representation. Stability across individuals can similarly be achieved by assuming that a) (conversational) situations imply restraints relevant for the representation and that b) generally individuals are likely to have similar experiences due to the common cognitive system and socio-cultural conventions (cf. Barsalou, 1999).

Furthermore, whereas previous research within the embodied cognition framework has shown that concept representations can be dynamic (e.g., Borghi et al., 2004; Glenberg & Kaschak, 2002; Zwaan et al., 2004), the current research to our knowledge provides the first experimental evidence that this representational flexibility has implications for an individual's processing experience *per se*. Despite the processing difficulty associated with modality-switching, participants reported

more (implicit) positive affect and evaluated multi-modality concepts more positively than single-modality concepts. Specifically, encoding concepts with multi-modality properties as compared to single-modality properties elevated their explicit evaluation to the same extent as the well-known mere-exposure effect (Bornstein, 1989; Zajonc, 1968). This is remarkable and further supports the idea that multi-modal experiences foster familiarity.

Chapter 5

Can't Read It, Must Eat It: Processing Fluency and Self-Control

This chapter is based on:

Regenberg, N. F. E., Häfner, M., & Semin, G. R. (2010). *Can't read it, must eat it. Processing fluency and self-control*. Manuscript in preparation.

Abstract

Processing fluency is the subjective ease with which individuals process information, which can significantly affect judgments and decision making. However, little is known about the functional value of such fluency experiences. We propose that (dis)fluency has a function for self-regulation, such that the experience of disfluency signals the need to upregulate self-control. According to the limited-resource model of self-regulation (Muraven & Baumeister, 2000), all acts of self-control draw on one common resource, undermining subsequent attempts of self-control. We hypothesized that disfluency decreases the resources available for self-control. In two experiments, we manipulated perceptual fluency and subsequently assessed participants' capacity for self-control. After experiencing perceptual disfluency, participants gave up more quickly on an unsolvable task (Experiment 1) and failed to resist a temptation (Experiment 2). Our findings therefore corroborate the idea that fluency experiences are important for self-regulation.

Imagine going out for dinner to a new restaurant. When reading through the menu, you have to focus a little, because it is written in a difficult-to-read font, but, in general, you start getting the feeling that you are at a very fancy restaurant where the dishes require an exceptionally skillful cook. Without you noticing, your judgment of how effortful the preparation of the dishes is may have been influenced by the processing difficulty of reading the menu, as research shows that experiencing processing ease or difficulty can affect effort predictions (Song & Schwarz, 2008b). However, will the effort you spend on reading this menu as compared to an easy-to-read menu also make it harder for you to resist the temptation to order a chocolate tart as dessert or to follow the waiter's suggestion to order a selection of appetizers even though you're not actually that hungry? In the present work, we examine the hypothesis that the experience of processing difficulty, or disfluency, draws on self-regulatory resources, which are subsequently unavailable for self-regulation.

Much research suggests that the metacognitive experiences during information processing, such as a feeling of processing ease or difficulty, influence an individual's judgments above and beyond the information's declarative value. Most prominently, easy-to-process stimuli are typically liked more than difficult-to-process stimuli (Bornstein, 1989; Reber et al., 1998; Zajonc, 1968) and produce a positive affective response (Winkielman & Cacioppo, 2001). In general, any cognition can be placed on a continuum from effortless to effortful and generates a corresponding metacognitive experience ranging from fluent to disfluent (Alter & Oppenheimer, 2009). For example, a menu can be easy or difficult to read, stock names can be easy or difficult to pronounce, or aphorisms can rhyme vs. not. A vast amount of research shows that such ubiquitous cues and their resulting fluency experience affect judgments, as the dishes on the difficult-to-read menu are thought to require more effort (Song & Schwarz, 2008b), easy-to-pronounce stock names outperform difficult-to-pronounce stock names (Alter & Oppenheimer, 2006), and rhyming aphorisms seem truer than non-rhyming aphorisms (McGlone & Tofiqbakhsh, 2000). Processing fluency can further lead to feelings of

familiarity (e.g., Whittlesea & Williams, 1998) and feelings of confidence (e.g., Novemsky et al., 2007). Whereas previous research has addressed various manipulations and outcome variables of processing fluency (cf. Alter & Oppenheimer, 2009; Schwarz, 2004; Schwarz et al., 2008), we sought to examine the *functional value* of such fluency experiences.

We propose that the experience of fluency is instrumental to adapt ongoing cognitions to the situation at hand and that the metacognitive feelings triggered by disfluency promote self-control. Particularly, we assume that the experience of disfluency provides information that the current situation is problematic, creating the need to upregulate self-control, as more effortful processing might be required. Indeed, theories of situated cognition (cf. Schwarz, 2002; E. R. Smith & Semin, 2004) assume that our cognitive processes are tuned to the characteristics and requirements of the situation. Affective responses within a situation, including metacognitive experiences, can signal the need to adapt one's current processing style (cf. Schwarz, 2002; Schwarz & Clore, 1996). However, whereas there is abundant evidence for the effect of feelings on evaluative judgments (cf. Winkielman et al., 2002) and on processing styles (cf. Schwarz, 2002), we aim to show that the metacognitive feeling of disfluency and the more effortful processing style it coincides with generally influence an individual's capacity for self-control.

Self-control is fundamental to every-day functioning, as we often need to override or interrupt immediate responses to attain our goals (Carver & Scheier, 1998). We may, for example, need to effortfully override an impulsive reaction, such as ordering a chocolate tart when we have a dieting goal. According to the strength model of self-control (Muraven & Baumeister, 2000), individuals have access to a common, but limited resource for self-regulation. Any exertion of self-control draws on – and depletes – this resource, which will therefore be unavailable for subsequent acts of volition (Muraven, Tice, & Baumeister, 1998). Abundant evidence has accumulated corroborating this idea of resource depletion (for a recent review see Hagger, Wood, Stiff, & Chatzisarantis, 2010). In the current work, we present a novel inte-

gration of these findings with research on processing fluency. Based on the assumption that fluency is functional for self-monitoring and self-control, we hypothesize that experiencing disfluency increases self-control, thereby depleting the general resource. Thus, after a disfluency experience, an individual should perform worse on a secondary task requiring self-control.

The idea that fluency plays a role for self-control has been implicitly addressed by previous research on fluency effects. For instance, Alter and colleagues (Alter, Oppenheimer, Epley, & Eyre, 2007) showed that the experience of disfluency lead participants to adopt a deeper, more analytic processing style, suggesting that fluency not only directly affects judgments (cf. Schwarz, 2004), but also provides a mechanism for strategy selection (see also Häfner & Stapel, 2009, 2010). In one experiment, participants who received information in a difficult-to-read font engaged in more systematic processing and relied less on (faulty) heuristics than participants who received the information in an easy-to-read font (Schwarz, 2004). Similarly, Song and Schwarz (2008a) demonstrated that individuals are less likely to fall prey to misleading questions, as “How many animals of each kind did Moses take on the arc?” (the biblical actor was Noah, not Moses) when the questions are presented in a difficult-to-read vs. an easy-to-read font. Moreover, research particularly in the domains of learning and memory (cf. Koriat, Ma’ayan, & Nussinson, 2006) similarly suggests that metacognitive experiences, such as a feeling of processing fluency, “are essential constituents of the self-regulation process” (Efklides, 2008, p. 277), as they “make the person aware of the state of his or her cognition and trigger control processes that serve the pursued goal of the self-regulation process” (Efklides, 2008, p. 282; see also Koriat, 2007; T. O. Nelson & Narens, 1994). For example, the experience of ease-of-learning influences study strategies, such that more time is allocated to items with a comparatively low ease-of-learning (T. O. Nelson & Leonesio, 1988; Son & Metcalfe, 2000). These examples seem to suggest that disfluency is functional in that it triggers self-control processes to deploy more resources to the difficult items in order to master them. We assume that

the experience of disfluency is generally associated with increased attempts of self-regulation. While this might be functional in the domain at hand (e.g., studying the items), the common resources available for self-regulation should become depleted and therefore less available for subsequent attempts of self-control.

In the current research, we sought to directly test the premise that the experience of disfluency triggers self-control processes. We predicted that processing information in a disfluent way depletes self-regulatory resources, leading to impoverished self-control afterwards. In Experiment 1, participants received the instructions for a task measuring persistence in an easy-to-read vs. a difficult-to-read manner. In Experiment 2, we investigated the effect of perceptual (dis)fluency on behavioral self-control by assessing whether chronic dieters would be more susceptible to choose a chocolate bar over an apple for filling in a questionnaire when the questionnaire had been difficult vs. easy to read.

5.1 Experiment 1: Persistence on an Unsolvable Task

We hypothesized that experiencing disfluency as compared to fluency depletes self-regulatory resources and therefore deteriorates an individual's persistence on a secondary task. We manipulated fluency vs. disfluency by giving participants easy-to-read vs. difficult-to-read instructions (cf. Song & Schwarz, 2010) and thereafter assessed resource depletion by measuring how long they would persist on an unsolvable task: Participants had to find the difference between two images which were actually identical (Koch et al., 2009). Persistence on an unsolvable task measures self-regulatory depletion, because persistence requires overriding the appealing response of quitting (Muraven et al., 1998). We thus expected participants in the disfluent condition to give up sooner than participants in the fluent condition.

5.1.1 Method

Participants and design

Twenty-nine students participated in the experiment for a monetary reward or course-credit and were randomly assigned to the fluent or disfluent condition. We excluded the data of two participants because they failed to follow the experimental instructions in an unrelated part of the experiment.

Procedure

The experiment was introduced as a new part of a longer experimental session. Participants were individually seated in cubicles and received all instructions from a computer. We manipulated fluency by varying the font in which the instructions were written: either easily readable (Arial) or difficult to read (Mistral). We told participants that they would do a search puzzle in which they had to look for the difference between two images. We told them to press “a” once they had found the difference and that they would then get the opportunity to describe it, or that they could press “b”, if they wanted to stop or abort. In order to deconfound the reading time for the instructions with the time participants spent on the actual task, the experiment was programmed in a way that participants read the instructions and then had to click on a button to make the (actually identical) images appear. The dependent variable was the time participants spent looking at the images, i.e., from pressing the button to make the images appear until they pressed “a” or “b”. We also measured the reading time for the instructions as a manipulation check: Participants in the disfluency condition should take longer than participants in the fluency condition.

5.1.2 Results and Discussion

A regression analysis of the fluency condition on the reading times confirmed that participants required more time to read the disfluent instructions ($M = 35.72$ seconds, $SD = 12.58$, $n = 13$) than the fluent instructions ($M = 23.36$ seconds, $SD = 10.33$, $n = 14$), $t(25) = 2.80$, $p = .010$, $\beta = .49$. More importantly, as predicted, participants in the fluent condition spent significantly more time on trying to find the difference between the two images ($M = 124.31$ seconds, $SD = 70.97$) than participants in the disfluent condition ($M = 66.19$ seconds, $SD = 22.78$), $t(25) = -2.82$, $p = .009$, $\beta = -.49$. The strength of this finding – participants in the fluent condition persisted twice as long as participants in the disfluent condition – lends strong support for the hypothesis that the experience of disfluency depletes self-regulatory resources. However, the experiment does not allow a conclusive argument of resource depletion, as difficult-to-read instructions might also have decreased participants' motivation to invest effort in the experiment leading to less persistence irrespective of self-regulatory resources. Although Muraven and Baumeister (2000) have suggested that motivation and self-control strength may interact in determining self-regulation rather than being mutually exclusive explanations, we sought a second experiment to investigate the effect of perceptual fluency on an unrelated, behavioral measure, rendering motivation irrelevant to the measure.

5.2 Experiment 2: Resisting Temptation

We designed this experiment to provide converging evidence for the idea that experiencing disfluency depletes self-regulatory resources while excluding motivation as an alternative explanation. Participants filled in a questionnaire that was manipulated to be easy vs. difficult to read. Afterwards, they could choose between an apple and a chocolate bar as compensation for their participation. We assumed that this choice poses a self-regulatory challenge for restrained eaters (Herman & Polivy,

1980), who are chronically concerned with their food intake. While they might want the chocolate, they should override this response and choose the apple instead. However, as this requires self-regulatory resources, we predicted that after filling in the disfluent questionnaire, restrained eaters would fail at this self-regulatory attempt, such that they are more likely to choose the chocolate over the apple. For unrestrained eaters, on the other hand, the choice between apple and chocolate should not involve self-regulation and we didn't expect an effect of the fluency manipulation on their choice.

5.2.1 Method

Participants and design

We received complete questionnaires from 70 participants (five additional participants failed to fill in the restrained eating questionnaire and three wanted neither an apple nor a chocolate bar). We excluded five participants from the analyses, because they indicated to be currently dieting to loose weight, as prior research indicates that current dieters are typically better at regulating (impulsive) eating (Guerrieri, Nederkoorn, Schrooten, Martijn, & Jansen, 2009; cf. Lowe, 1993). The resulting sample of 65 participants was distributed equally across both experimental conditions (33 in the fluent condition).

Procedure

Participants were approached in a computer work-room at the university and asked whether they could fill in a 10-minute questionnaire. They then received a 48-item Big Five questionnaire, which was either printed black on white (fluent) or with the font color in a 30% gray shade on white (disfluent), making it look like a barely readable photocopy. Upon completing their questionnaire, they were to approach the experimenter

and could choose between receiving an apple and a chocolate bar for participating in the experiment. The apple and the chocolate bar were of an approximately equal monetary value. After making their choice, participants received a second questionnaire, which was well-readable in both conditions. It included a one-item mood measure (“How do you feel at this moment?”) to be answered on a 7-point Likert scale from 1 = ‘*bad*’ to 7 = “*good*”. Furthermore, we assessed the participants’ experience while filling in the Big Five questionnaire, including the amount of experienced pleasure, enjoyment, motivation, difficulty, exhaustion, and their perception of the questionnaire’s layout and readability, all responded to on 7-point Likert scales. The last two items served as a manipulation check of our fluency manipulation; we included the other items to assess potential confounds of the expected depletion effect. Finally, participants filled in the Dutch version of the concern for dieting subscale of the revised restrained scale (Herman & Polivy, 1980; Jansen, Oosterlaan, Merckelbach, & Hout, 1988). This scale consists of six items that assess participants’ chronic motivation to control their weight by dieting, e.g., “*How conscious are you of what you are eating?*” and “*I feel guilty after having eaten too much*”. Due to reliability concerns we dropped the item “*Would a weight fluctuation of 2.5 kilograms (ca. 5 lb) affect the way you live your life?*”, resulting in reliable scale (Cronbach’s $\alpha = .83$). As the scale includes different answer formats, all analyses were done with a Z-transformed scale mean.

5.2.2 Results and Discussion

Manipulation checks and potential confounds

Participants thought that the layout of the questionnaire, $t(64) = -3.82$, $p < .001$, $\beta = -.43$, and readability of the questionnaire, $t(64) = -9.35$, $p < .001$, $\beta = -.76$, were significantly worse in the disfluent condition ($M_{layout} = 4.48$, $SD = 1.24$; $M_{readability} = 3.26$, $SD = 1.63$) than in the fluent condition ($M_{layout} = 5.42$, $SD = 0.75$; $M_{readability} = 6.27$, $SD =$

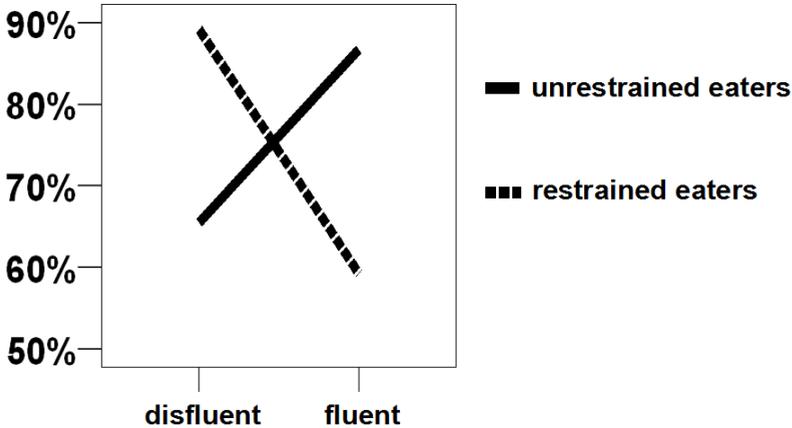


Figure 5.1: Predicted probability of choosing the chocolate as a function of restrained eating (operationalized as 1 *SD* above vs. below the scale mean) and the fluency manipulation in Experiment 2.

0.91). However, the fluency manipulation had no effect on participants' mood, $t(64) < 1$, their motivation, $t(64) < 1$, their enjoyment of filling in the questionnaire, $t(64) < 1$, the amount of pleasure they experienced, $t(64) = -1.10$, $p = .28$, $\beta = -.14$, the difficulty they experienced, $t(64) = 1.57$, $p = .12$, $\beta = .19$, or how exhausted they felt, $t(64) < 1$.

Choice for apple or chocolate

To assess the hypothesis that the effect of the fluency manipulation on the participants' choice for the apple vs. the chocolate would be moderated by their score on the restrained eating scale, we performed a logistic regression analysis following the procedure suggested by Hayes and Matthes (2009) with the fluency manipulation as a categorical independent variable ($fluent = 0$; $disfluent = 1$) and the restrained eating scale as the moderator. It yielded no main effect of the fluency condi-

tion, $Wald \chi^2(df = 1) = 0.15$, $p = .697$, $B = -0.25$, $Exp(B) = .78$, no main effect of restrained eating, $Wald \chi^2(df = 1) = 2.10$, $p = .147$, $B = 0.98$, $Exp(B) = 2.67$, but the expected interaction between fluency and restrained eating, $Wald \chi^2(df = 1) = 4.82$, $B = -1.99$, $p = .028$, $Exp(B) = 0.14$, 95% $CI[0.02, 0.81]$. We further explored this interaction by analyzing the conditional effects of the fluency manipulation for restrained eaters (1 SD above the mean) and for unrestrained eaters (1 SD below the mean). For unrestrained eaters, fluency was not predictive of the participants' choice between chocolate and apple, $Wald \chi^2(df = 1) = 1.92$, $p = .165$, $B = 1.23$, 95% $CI[-0.51, 1.98]$, whereas for restrained eaters, the fluency manipulation made a marginally significant difference in the expected direction, $Wald \chi^2(df = 1) = 3.22$, $p = .073$, 95% $CI[-3.62, 0.16]$. Thus, restrained eaters tended to choose the chocolate more often after filling in the disfluent questionnaire than after filling in the fluent questionnaire (see Figure 5.1).

5.3 General Discussion

In the present experiments, we provided support for the hypothesis that experiencing disfluency depletes self-regulatory resources. In Experiment 1, participants who received instructions in a fluent manner persisted twice as long on an unsolvable task than participants who received the instructions in a disfluent manner. In Experiment 2, restrained eaters were more likely to choose a chocolate bar over an apple for participating in an experiment after filling in a disfluent questionnaire than after filling in a fluent questionnaire, whereas unrestrained eaters, for whom the choice between apple and chocolate posed no self-regulatory concern, were not influenced by the fluency manipulation. Our findings corroborate the idea that fluency experiences are important for self-regulation.

However, alternative explanations of our results are conceivable. First, our effects could merely be driven by the increased amount of cog-

nitive effort that is necessary to process disfluent vs. fluent stimuli without the requirement of self-regulation. However, we think that this explanation is unlikely given that non-regulatory effortful tasks have been used as a control condition in experiments investigating self-regulation (e.g., Muraven et al., 1998, Experiment 3). Second, another explanation could be that disfluency decreased participants' motivation to do the task (Experiment 1) or produced the feeling that they "deserved" the chocolate as a reward after filling in the difficult-to-read questionnaire (Experiment 2). However, our fluency manipulation had no effect on participants' self-reported motivation or enjoyment while filling in the questionnaire in Experiment 2. Moreover, neither the motivation nor the reward explanation would predict an interaction between our fluency manipulation and restrained eating – which we hypothesized and found based on the idea that fluency experiences play a role in self-control. Therefore, both the motivation and reward explanations seem unlikely.

Although effects of self-regulatory depletion have been linked to subjective effort and task difficulty (cf. Hagger et al., 2010; Muraven & Baumeister, 2000), our contribution is novel as we introduce disfluency as a subtle and unobtrusive manipulation of self-regulation. Whereas prior research has often employed the effortful suppression of an impulse or the overriding of a habitual response (cf. Hagger et al., 2010), we demonstrate that even subtle changes, such as the font in which instructions are printed, can draw upon self-regulatory resources.

Moreover, our findings provide valuable insights into the functional role of processing fluency. Whereas previous research has largely focused on the impact fluency has on judgments and decision making (cf. Alter & Oppenheimer, 2009; Schwarz, 2004), the current experiments reveal directly and for the first time that processing fluency plays a role in self-regulation. Processing disfluent information depletes self-regulatory resources. Overall, our results are of potential interest, for instance, for our understanding of consumer behavior: Individuals might be per-

suaded more easily into having the chocolate dessert if the menu is written in a difficult-to-read font or to comply with a charitable request (cf. Fennis, Janssen, & Vohs, 2009) when first filling in a difficult-to-read questionnaire.

Chapter 6

General Discussion

The present dissertation explored different antecedents and consequences of processing fluency. I investigated how feelings of fluency can be triggered by visuo-motor and sensory experiences. Moreover, I explored the role of fluency for self-regulation. I will now summarize my main results while providing a brief sketch of their position within and contribution to existing theories and empirical work. In addition, I will outline new research questions which my findings have sparked.

6.1 Fluency From the Motor System

6.1.1 Summary

In Chapters 2 and 3 of this dissertation I applied an ecological approach to perception and action. Accordingly, I assumed that individuals interpret the meaning of a situation by automatically analyzing their action capabilities within the situation, in other words, by deriving action affordances. Therefore, perceptual properties of the environment

should drive an individual's construal of the situation. I hypothesized that acting in line with perceived action affordances would be notably easier than acting against such affordances. This facilitation has previously been shown within a number of experiments employing a stimulus-response paradigm (e.g., Symes et al., 2007; Tucker & Ellis, 1998, 2001, 2004). Such experiments consistently find that participants respond faster and more accurately when the perceived affordances match the required response.

Based on the considerable amount of research on the effects of processing fluency (cf. Schwarz, 2004) and the assumption that any variable that facilitates processing should give rise to fluency effects (cf. Alter & Oppenheimer, 2009), I hypothesized that the ease associated with performing afforded actions as compared to unafforded actions should equally produce feelings of fluency. In Chapter 2, I provided support for this hypothesis. Specifically, participants experienced a diffuse positive feeling after acting in congruence with perceived affordances and they were able to report a feeling of fluency. These findings are in line with recent similar research, showing that acting in congruence with action affordances produces positive affect, as measured by facial EMG (Cannon et al., 2010). In addition, the results of Chapter 2 provide a valuable extension in that they show that individuals have access to this fluency experience and can consciously report on it. Moreover, I measured participants' feeling state by asking them to evaluate neutral objects, namely Chinese ideographs. The fact that these evaluations were driven by perceptuo-motor fluency provides strong support for our hypotheses, as the ideographs were unrelated to the actual fluency experience. Participants' feeling state thus even transferred to an unrelated target (cf. Monahan, Murphy, & Zajonc, 2000, Experiment 2).

In sum, my findings imply that fluency can be triggered by perceptuo-motor processes and thus corroborate the underpinnings of ecological theories of perception (Gibson, 1979) and generally theories assuming a direct coupling between perception and action (Hommel et al., 2001; Prinz, 1997; E. R. Smith & Semin, 2004). Moreover, the research

described in Chapter 3 further supports and extends this notion: Not only can acting within an environment produce feelings of fluency when the actions are congruent with perceived affordances, but the perception of an easy vs. a more difficult course of action can also drive choice preferences. Thus, not only are afforded actions easier, the mere anticipation of such processing ease already affects judgments. Chapter 3 further provides valuable insights into the mechanics of such bodily cues. The results show that affordances are clearly body-specific, but nevertheless malleable depending on the situational context. This is evidence in support of the view that our cognitive processes are embodied and dynamically situated (cf. Marsh, Johnston, Richardson, & Schmidt, 2009).

6.1.2 Outlook

Influence on judgments and decision making

Prior research has demonstrated that processing fluency can affect a vast range of judgments. For example, fluency not only produces positive affect (Häfner & Stapel, 2010; Monahan et al., 2000; Winkielman & Cacioppo, 2001), but can also influence an individual's liking for a stimulus (Bornstein & D'Agostino, 1992; Reber et al., 1998; Zajonc, 1968), affect the truth value assigned to the processed information (Reber & Schwarz, 1999; McGlone & Tofiqbakhsh, 2000), increase the confidence one has in a current judgment (Alter et al., 2007; Novemsky et al., 2007), and lead to a higher valuation of the information (Alter & Oppenheimer, 2006, 2008; Shah & Oppenheimer, 2007). The research reported in this dissertation is merely a starting point to explore whether fluency can be triggered by the motor system and is limited to demonstrating that the interaction between perception and action produce feelings of fluency and positive affect. These findings hence raise the question whether (anticipated) physical interactions with one's environment can equally produce fluency outcomes on other variables. Indeed, an experiment

by Hayes et al. (2008) demonstrates that individuals like objects better after fluent interactions with them than after disfluent interactions. But it is up to future research to show whether other outcomes, which have previously been found for perceptual or conceptual fluency, can be applied to perceptuo-motor fluency. For example, would we place more confidence in a tool that we have used fluently or would we overestimate its usefulness compared to a tool we have used less fluently? Also a more applied link to consumer psychology is conceivable: Would we value an object more if we've had an easy interaction with it and would we therefore be willing to spend more money on it?

Fluency from bottom-up vs. top-down processes

In the current research, I have placed particular emphasis on the situatedness of affordances and the resulting fluency effects. Within the framework of ecological psychology, affordances arise from the interaction between an individual's capabilities and the situation, thus focusing on the dynamics of the interaction (cf. Marsh et al., 2009). In the research reported in this dissertation, these action capabilities were always operationalized as physical properties. For example, the cups could be grabbed with one's left or right hand (Chapter 2), or I investigated the action preferences of left- and right-handers, or of right-handers acting with their left or right hand (Chapter 3). However, it is likely that intrapersonal variables also influence an individual's construal of a situation. For example, individuals overestimate the height of a balcony more after a manipulation of arousal (Stefanucci & Storbeck, 2009). Similarly, height perception is influenced by fear (Clerkin, Cody, Stefanucci, Proffitt, & Teachman, 2009; Stefanucci, Proffitt, Clore, & Parekh, 2008). This means that not only physical, bodily variables determine how we perceive the environment, but psychological variables such as an emotional state or a disposition can also play a role. Likewise, goals can influence and modulate sensorimotor representations (Bub & Masson, 2010). Thus, feelings of fluency may not only arise as a function of physical affordances. Rather, internal mental states might be equally

important (cf. Sebanz & Knoblich, 2009). Future research might profit from an analysis of the extent to which sensorimotor fluency experiences are situated within a “bottom-up”, environmentally driven perception and to what extent “top-down” internal states play a role.

Interpersonal action fluency

Finally, in the present research, I explored the effects of one individual’s perceptions and actions on the experience of fluency. However, in many situations, we act jointly with others. Based on the idea that perception and action share common neural substrates (Prinz, 1997), Sebanz and colleagues (Sebanz, Knoblich, & Prinz, 2003) predicted and found that when performing a shared task, individuals automatically represent the actions of others as if they were their own – even though this led to a decreased performance than when participants executed the task alone. Thus, if participants perceive affordances for another person, it is conceivable that the fluency experienced from acting in congruence with these affordances could also be “shared”. For example, would we like an object more, if we observe another person’s fluent interaction with it as compared to a disfluent interaction? There is some experimental support for this suggestion. In two experiments, participants watched movie clips of another person’s fluent or disfluent interaction with an object (A. E. Hayes et al., 2008). The observers indeed liked objects more after viewing fluent interactions with them – at least when the actor’s gaze was visible. Thus, interpersonal action fluency effects seem possible, but their conditions and limitations have yet to be investigated.

6.2 Fluency From Multimodal Conceptual Thought

6.2.1 Summary

While Chapters 2 and 3 dealt with actual interactions with one's environment, in Chapter 4, I explored whether even conceptual thought can give rise to embodied fluency effects. Particularly, I predicted that the experience of fluency during conceptual thought, such as language comprehension, is contingent on one's ease of constructing a concept's meaning. According to perceptual theories of knowledge (Barsalou, 1999; Glenberg, 1997) concept representations are dynamic and situationally construed. Moreover, conceptual thought is believed to be modality-specific. In other words, the same concept might invoke a dominantly tactile representation in one situation and a dominantly visual representation in another. In line with previous findings, I hypothesized that the construction of meaning should be facilitated by representational richness (Myers et al., 1984; E. E. Smith et al., 1978) and predicted that representational richness, in turn, is increased by including more modalities into a concept's representation.

The findings reported in Chapter 4 support this hypothesis. Concepts encoded within a multi-modal processing (e.g., visual, auditory, and tactile) context gained a richer semantic representation than concepts encoded within a single-modality (e.g., visual) context. Moreover, my findings show that this has consequences for an individual's processing experience per se. Participants reported more positive mood after multi-modal processing and they liked concepts associated with multi-modal properties better than concepts associated with properties from one modality.

These findings are intriguing, because previous research within the embodied cognition approach has exclusively focused on the costs associated with switching between modalities while processing (Pecher et al.,

2003, 2004; Van Dantzig et al., 2008; Vermeulen et al., 2008). My findings show that albeit this initial cost, there is ultimately an advantage to multi-modality processing, as reflected in the recognition speed for previously encoded concepts and in participants' subjective processing experience.

6.2.2 Outlook

Multi-modal mere exposure

In the second experiment discussed in Chapter 4, the processing dynamics of concepts encoded with multi-modal properties were assessed against a mere-exposure control condition. Simply presenting concepts with multi-modal properties caused an equal increase in the evaluation of these concepts as the well-documented mere-exposure effect (cf. Bornstein, 1989). It might be relevant to consider the implications of this finding, for example, when designing stimulus materials for any arbitrary experiment. Pairing multi-modal properties with some stimuli but not with others might unintentionally bias the evaluation of otherwise neutral stimuli.

Furthermore, given the apparent strength of the effect on the stimulus evaluations, it might be useful to further explore the interactions between mere-exposure contexts and multi-modality processing. In the current experiment, a ceiling effect was found regarding the repeated presentation of single-modality concepts as compared to multi-modality concepts. However, a further exploration of these interactions is warranted as the effects of mere-exposure might even be augmented by multi-modal exposure.

6.3 Fluency and Self-Regulation

6.3.1 Summary

In Chapter 5, I more generally explored the role of processing fluency for the self. Rather than assessing possible causes of fluency within the perception and action systems, I addressed self-regulatory depletion as a possible consequence of experiencing disfluency. Particularly, I investigated the possibility that disfluency provides an internal feedback signal about ongoing cognitive processes, informing an individual about the need to adapt one's current processing style. I assumed this adaptation to be an act of self-control, which should hence draw on the limited resources available for self-regulation (Muraven & Baumeister, 2000). Therefore, I hypothesized that individuals would be less able to exert self-control after an experience of disfluency.

In two experiments involving different measures of regulatory depletion, this hypothesis was supported. These findings are hence consistent with the hypothesis that our cognitive processes are situated to meet situational demands (cf. Schwarz, 2002; E. R. Smith & Semin, 2004). Furthermore, these results corroborate the idea that our perception and understanding of both the environment and our own cognitions is tuned to function cost-effectively, leading to adaptive behavior. The findings of Chapter 5 thereby suggest that a possible function of processing fluency is to preserve the “economy of action” (p. 110, Proffitt, 2006).

6.3.2 Outlook

Robustness of the effect

To my knowledge, Chapter 5 offers the first test of the effect of processing fluency on self-regulatory depletion. Despite the fascination and interest that regulatory depletion effects seem to receive within the scientific

community (cf. Hagger et al., 2010), as any novel line of research, the effect should be subjected to close scrutiny and further exploration and replication. Nevertheless, the results of the current dissertation offer a promising starting point for such investigations.

Source of the disfluency experience

In the current experiments, the experience of disfluency was unrelated to the measure of self-regulation as is typically the case in regulatory depletion paradigms (cf. Muraven & Baumeister, 2000). However, the argument underlying the current hypotheses is that disfluency signals the need to change one's current processing style. Therefore, individuals might actually become better at self-regulation in the domain in which disfluency was experienced. For example, if participants filled in a questionnaire about "healthy eating", which is manipulated to be easy- or difficult-to-read, would chronic dieters be more successful at refusing the chocolate after filling in the disfluent questionnaire because of an increased self-regulatory effort to "eat healthy"?

Depletion and other fluency outcomes

A question unanswered by the current research concerns the relationship between self-regulation and other fluency outcomes. It is well established that fluency can influence a vast array of judgments and decision making (cf. Schwarz, 2004; Alter & Oppenheimer, 2009). What is the role of self-regulatory depletion in determining these outcomes? It remains up to future research to explore these links and to analyze whether self-regulatory depletion is merely a by-product of experiencing disfluency or whether there is a causal relation to other fluency outcomes.

6.4 Coda

The research in this dissertation demonstrates that we are influenced by the way in which we physically interact with our environment. Paralleling the effects on perceptual and conceptual fluency, smooth interactions not only feel easy, but they elevate an individual's tonic mood state. Thus, the meaning of a situation lies in the action possibilities perceived within it, which are contingent on constraints imposed by one's own body and the environment. Similarly, even the meaning of understanding concepts, for example, during language comprehension, is contingent on bodily-driven, sensorimotor representations. The current research shows that the ease to derive meaning from concepts is increased when more sources of sensory information are available.

I suggest that metacognitive experiences, such as a feeling of fluency, are functional because they reward and promote easy, cost-effective behavior. Therefore, the experience of disfluency should also signal the need to adapt current processes to better meet the contextual requirements. My research provides initial support for this hypothesis. In sum, this dissertation corroborates the view that fluency is a hedonic cue which is a functional signal to maintain the status-quo or to initiate a cognitive or behavioral change.

References

- Alter, A. L., & Oppenheimer, D. M. (2006). Predicting short-term stock fluctuations by using processing fluency. *Proceedings of the National Academy of Science*, *103*, 9369–9372. doi:10.1073/pnas.0601071103
- Alter, A. L., & Oppenheimer, D. M. (2008). Easy on the mind, easy on the wallet: The effects of familiarity and fluency on currency valuation. *Psychonomic Bulletin and Review*, *15*, 985–990. doi:10.3758/PBR.15.5.985
- Alter, A. L., & Oppenheimer, D. M. (2009). Uniting the tribes of fluency to form a metacognitive nation. *Personality and Social Psychology Review*, *13*, 219–235. doi:10.1177/1088868309341564
- Alter, A. L., Oppenheimer, D. M., Epley, N., & Eyre, R. N. (2007). Overcoming intuition: Metacognitive difficulty activates analytic reasoning. *Journal of Experimental Psychology: General*, *136*, 569–576. doi:10/1037/0096-3445.136.4.569
- Bargh, J. A., & Chartrand, T. L. (2000). The mind in the middle: A practical guide to priming and automaticity research. In H. T. Reis & C. Judd (Eds.), *Handbook of research methods in social and personality psychology* (pp. 253–285). Cambridge University Press, Cambridge, MA.
- Barsalou, L. W. (1983). Context-independent and context-dependent information in concepts. *Memory and Cognition*, *10*, 82–93.

- Barsalou, L. W. (1993). Flexibility, structure, and linguistic vagary in concepts: Manifestations of a compositional system of perceptual symbols. In A. F. Collins, S. E. Gathercole, M. A. Conway, & P. E. Morris (Eds.), *Theories of memory* (pp. 30–89). Erlbaum, Hove, U.K..
- Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*, 577–609. doi:10.1017/S0140525X99002149
- Barsalou, L. W. (2003). Situated simulation in the human conceptual system. *Language and Cognitive Processes*, *18*, 513–562. doi:10.1080/01690960344000026
- Barsalou, L. W. (2008). Grounding symbolic operations in the brain’s modal systems. In G. R. Semin & E. R. Smith (Eds.), *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches* (pp. 9–42). Cambridge University Press, New York.
- Beilock, S. L., & Holt, L. E. (2007). Embodied preference judgments. Can likability be driven by the motor system? *Psychological Science*, *18*, 51–57. doi:10.1111/j.1467-9280.2007.01848.x
- Bergh, O. Van den, Vrana, S., & Eelen, P. (1990). Letters from the heart: Affective categorization of letter combinations in typists and nontypists. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 1153–1161. doi:10.1037/0278-7393.16.6.1153
- Bhalla, M., & Proffitt, D. R. (1999). Visual-motor recalibration in geographical slant perception. *Journal of Experimental Psychology: Human Perception & Performance*, *25*, 1076–1096. doi:10.1037/0096-1523.25.4.1076
- Borghi, A. M., Glenberg, A. M., & Kaschak, M. P. (2004). Putting words in perspective. *Memory and Cognition*, *32*, 863–873. Retrieved from <http://mc.psychonomic-journals.org/content/32/6/863.full.pdf>
- Bornstein, R. F. (1989). Exposure and affect: Overview and meta-analysis of research 1968-1987. *Psychological Bulletin*, *106*, 265–289. doi:10.1037/0033-2909.106.2.265
- Bornstein, R. F., & D’Agostino, P. R. (1992). Stimulus recognition and the mere exposure effect. *Journal of Personality and Social Psychology*, *63*, 545–552. doi:10.1037/0022-3514.63.4.545

- Bub, D. N., & Masson, M. E. J. (2010). Grasping beer mugs: On the dynamics of alignment effects induced by handled objects. *Journal of Experimental Psychology: Human Perception and Performance*, *36*, 341–358. doi:10.1037/a0017606
- Cannon, P. R., Hayes, A. E., & Tipper, S. P. (2010). Sensorimotor fluency influences affect: Evidence from electromyography. *Cognition and Emotion*, *24*, 681–691. doi:10.1080/02699930802234864
- Carver, C. S., & Scheier, M. F. (1998). *On the self-regulation of behavior*. Cambridge University Press, Cambridge, UK.
- Casasanto, D. (2009). Embodiment of abstract concepts: Good and bad in right and left handers. *Journal of Experimental Psychology: General*, *138*, 351–367. doi:10.1037/a0015854
- Chen, Y.-C., & Spence, C. (2010). When hearing the bark helps to identify the dog: Semantically-congruent sounds modulate the identification of masked pictures. *Cognition*, *114*, 389–404. doi:10.1016/j.cognition.2009.10.012
- Clark, A. (1997). *Being there*. MIT Press, Cambridge, MA.
- Clerkin, E. M., Cody, M. W., Stefanucci, J. K., Proffitt, D. R., & Teachman, B. A. (2009). Imagery and fear influences height perception. *Journal of Anxiety Disorders*, *23*, 381–386. doi:10.1016/j.janxdis.2008.12.002
- Efklides, A. (2008). Metacognition: Defining its facets and levels of functioning in relation to self-regulation and co-regulation. *European Psychologist*, *13*, 277–287. doi:10.1027/1016-9040.13.4.277
- Fennis, B. M., Janssen, L., & Vohs, K. (2009). Acts of benevolence: A limited-resource account of compliance with charitable requests. *Journal of Consumer Research*, *35*, 906–924. doi:10.1086/593291
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Houghton Mifflin, New York.
- Gilbert, A. N., & Wysocki, C. J. (1992). Hand preference and age in the united states. *Neuropsychologia*, *30*, 601–608. doi:10.1016/0028-3932(92)90065-T
- Gill, M. J., Swan, W. B., & Silvera, D. H. (1998). On the genesis of confidence. *Journal of Personality and Social Psychology*, *75*, 1101–1114. doi:10.1037/0022-3514.75.5.1101

- Glenberg, A. M. (1997). What memory is for. *Behavioral and Brain Sciences*, *20*, 1–55. doi:10.1017/S0140525X97000010
- Glenberg, A. M., Becker, R., Klötzer, S., Kolanko, L., Müller, S., & Rinck, M. (2009). Episodic affordances contribute to language comprehension. *Language and Cognition*, *1*, 113–135. doi:10.1515/LANGCOG.2009.006
- Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin and Review*, *9*, 558–565. Retrieved from <http://pbr.psychonomic-journals.org/content/9/3/558.full.pdf>
- Glenberg, A. M., & Robertson, D. A. (2000). Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning. *Journal of Memory and Language*, *43*, 379–401. doi:10.1006/jmla.2000.2714
- Greifeneder, R., Alt, A., Bottenberg, K., Seele, T., Zelt, S., & Wagener, D. (2010). On writing legibly: Processing fluency systematically biases evaluations of handwritten material. *Social Psychological and Personality Science*, *1*, 230–237. doi:10.1177/1948550610368434
- Grondin, R., Lupker, S. J., & McRae, K. (2009). Shared features dominate semantic richness effects for concrete concepts. *Journal of Memory and Language*, *60*, 1–19. doi:10.1016/j.jml.2008.09.001
- Guerrieri, R., Nederkoorn, C., Schrooten, M., Martijn, C., & Jansen, A. (2009). Inducing impulsivity leads high and low restrained eaters into overeating, whereas current dieters stick to their diet. *Appetite*, *53*, 93–100. doi:10.1016/j.appet.2009.05.013
- Häfner, M., & Stapel, D. A. (2009). Familiarity can increase and decrease stereotyping: Heuristic processing versus enhanced usability. *Social Cognition*, *27*, 615–622. doi:10.1521/soco.2009.27.4.615
- Häfner, M., & Stapel, D. A. (2010). Information to go: Fluency enhances the usability of primed information. *Journal of Experimental Social Psychology*, *46*, 73–84. doi:10.1016/j.jesp.2009.10.001
- Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin*, *136*, 495–525.

- doi:10.1037/a0019486
- Hansen, J., Dechêne, A., & Wänke, M. (2008). Discrepant fluency increases subjective truth. *Journal of Experimental Social Psychology, 44*, 687–691. doi:10.1016/j.jesp.2007.04.005
- Hansen, J., & Wänke, M. (2008). It's the difference that counts: Expectancy/experience discrepancy moderates the use of ease of retrieval in attitude judgments. *Social Cognition, 26*, 447–468. doi:10.1521/soco.2008.26.4.447
- Harmon-Jones, E., & Allen, J. J. B. (2001). The role of affect in the mere exposure effect: Evidence from psychophysiological and individual differences approaches. *Personality and Social Psychology Bulletin, 27*, 889–898. doi:10.1177/0146167201277011
- Harnad, S. (1990). The symbol grounding problem. *Physica D: Nonlinear Phenomena, 42*, 335–346. doi:10.1016/0167-2789(90)90087-6
- Hayes, A. E., Paul, M. A., Beuger, B., & Tipper, S. P. (2008). Self produced and observed actions influence emotion: The roles of action fluency and eye gaze. *Psychological Research, 72*, 461–472. doi:10.1007/s00426-007-0125-3
- Hayes, A. F., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior Research Methods, 41*, 924–936. doi:10.3758/BRM.41.3.924
- Herman, C. P., & Polivy, J. (1980). Restrained eating. In A. J. Stunkard (Ed.), *Obesity* (pp. 208–225). Saunders, Philadelphia, PA.
- Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences, 24*, 849–937. doi:10.1017/S0140525X01000103
- Jacoby, L. L., & Whitehouse, K. (1989). An illusion of memory: False recognition influenced by unconscious perception. *Journal of Experimental Psychology: General, 118*, 126–135. doi:10.1037/0096-3445.118.2.126
- Jansen, A., Oosterlaan, J., Merckelbach, H., & Hout, M. A. van den. (1988). Nonregulation of food intake in restrained, emotional, and external eaters. *Journal of Psychopathology and Behavioral*

- Assessment*, 10, 345–354. doi:10.1007/BF00960627
- Kaschak, M. P., & Glenberg, A. M. (2000). Constructing meaning: The role of affordances and grammatical constructions in sentence comprehension. *Journal of Memory and Language*, 43, 508–529. doi:10.1006/jmla.2000.2705
- Koch, S., Holland, R. W., Bordes, P. de, Hengstler, M., Somerdyk, C., & Knippenberg, A. van. (2009). *Approach-avoidance motor actions, glucose levels, and resource allocation: Avoidance instigates the mobilization of cognitive resources*. Manuscript in preparation.
- Koriat, A. (2007). Metacognition and consciousness. In P. D. Zelazo, M. Moscovitch, & E. Thompson (Eds.), *The cambridge handbook of consciousness* (pp. 289–325). Cambridge University Press, Cambridge, UK.
- Koriat, A., Ma'ayan, H., & Nussinson, R. (2006). The intricate relationship between monitoring and control in metacognition: Lessons for the cause-and-effect relation between subjective experience and behavior. *Journal of Experimental Psychology: General*, 135, 36–69. doi:10.1037/0096-3445.135.1.36
- Kounios, J., Green, D. L., Payne, L., Fleck, J. I., Grondin, R., & McRae, K. (2009). Semantic richness and the activation of concepts in semantic memory: Evidence from event-related potentials. *Brain Research*, 1282, 95–102. doi:10.1016/j.brainres.2009.05.092
- Laham, S. M., Alter, A. L., & Goodwin, G. P. (2009). Easy on the mind, easy on the wrongdoer: Discrepantly fluent violations are deemed less morally wrong. *Cognition*, 112, 462–466. doi:10.1016/j.cognition.2009.06.001
- Longo, M. R., & Lourenco, S. F. (2007). Space perception and body morphology: extent of near space scales with arm length. *Experimental Brain Research*, 177, 285–290. doi:10.1007/s00221-007-0855-x
- Lowe, M. (1993). The effects of dieting on eating behavior: A three-factor model. *Psychological Bulletin*, 114, 100–121. doi:10.1037/0033-2909.114.1.100
- Mark, L. S. (1987). Eyeheight-scaled information about affordances: A study of sitting and stair climbing. *Journal of Experimental Psychology: Human Perception and Performance*, 13, 361–370.

- doi:10.1037/0096-1523.13.3.361
- Marsh, K. L., Johnston, L., Richardson, M. J., & Schmidt, R. C. (2009). Toward a radically embodied, embedded social psychology. *European Journal of Social Psychology, 39*, 1217–1225. doi:10.1002/ejsp.666
- Mazzoni, G., & Nelson, T. (Eds.). (1998). *Metacognition and cognitive neuropsychology*. Erlbaum, Mahwah, NJ.
- McClelland, J. L., & Rumelhart, D. E. (1985). Distributed memory and the representation of general and specific information. *Journal of Experimental Psychology: General, 114*, 159–188. doi:10.1037/0096-3445.114.2.159
- McGlone, M. S., & Tofiqbakhsh, J. (2000). Birds of a feather flock conjointly (?): Rhyme as reason in aphorisms. *Psychological Science, 11*, 424–428. doi:10.1111/1467-9280.00282
- McRae, K., Cree, G. S., Seidenberg, M. S., & McNorgan, C. (2005). Semantic feature production norms for a large set of living and nonliving things. *Behavior Research Methods, 37*, 547–559. Retrieved from <http://brm.psychonomic-journals.org/content/37/4/547.full.pdf>
- Metcalf, J., & Shimamura, A. P. (Eds.). (1994). *Knowing about knowing*. MIT Press, Cambridge, MA.
- Monahan, J. L., Murphy, S. T., & Zajonc, R. B. (2000). Subliminal mere exposure: Specific, general, and diffuse affect. *Psychological Science, 11*, 462–466. doi:10.1111/1467-9280.00289
- Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*, 247–259. doi:10.1037//0033-2909.126.2.247
- Muraven, M., Tice, D. M., & Baumeister, R. (1998). Self-control as limited resource: regulatory depletion patterns. *Journal of Personality and Social Psychology, 74*, 774–789. doi:10.1037/0022-3514.74.3.774
- Murphy, S. T., & Zajonc, R. B. (1993). Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures. *Journal of Personality and Social Psychology, 64*, 723–739. doi:10.1037/0022-3514.64.5.723

- Myers, J. L., O'Brien, E. J., Balota, D. A., & Toyofuku, M. L. (1984). Memory search without interference: The role of integration. *Cognitive Psychology*, *16*, 217–242. doi:10.1016/0010-0285(84)90008-2
- Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (2004). The University of South Florida free association, rhyme, and word fragment norms. *Behavior Research Methods, Instruments & Computers*, *36*, 402–407. Retrieved from <http://brm.psychonomic-journals.org/content/36/3/402.full.pdf>
- Nelson, T. O., & Leonesio, R. J. (1988). Allocation of self-paced study time and the “labor-in-vain effect”. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *14*, 676–686. doi:10.1037/0278-7393.14.4.676
- Nelson, T. O., & Narens, L. (1994). Why investigate metacognition? In J. Metcalfe & A. Shimamura (Eds.), *Metacognition: Knowing about knowing* (pp. 1–25). MIT Press, Cambridge, MA.
- Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we know: verbal reports on mental processes. *Psychological Review*, *84*, 231–259. doi:10.1037/0033-295X.84.3.231
- Novemsky, N., Dhar, R., Schwarz, N., & Simonson, I. (2007). Preference fluency in choice. *Journal of Marketing Research*, *44*, 347–356. doi:10.1509/jmkr.44.3.347
- Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2003). Verifying different-modality properties for concepts produces switching costs. *Psychological Science*, *14*, 119–124. doi:10.1111/1467-9280.t01-1-01429
- Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2004). Sensorimotor simulations underlie conceptual representations: Modality-specific effects of prior activation. *Psychonomic Bulletin & Review*, *11*, 164–167. Retrieved from <http://pbr.psychonomic-journals.org/content/11/1/164.full.pdf>
- Pexman, P. M., Hargreaves, I. S., Edwards, J. D., Henry, L. C., & Goodyear, B. G. (2007). The neural consequences of semantic richness: When more comes to mind, less activation is observed. *Psychological Science*, *18*, 401–406. doi:10.1111/j.1467-

- 9280.2007.01913.x
- Pexman, P. M., Holyk, G. G., & Monfils, M.-H. (2003). Number-of-features effects and semantic processing. *Memory and Cognition*, *31*, 842–855. Retrieved from <http://mc.psychonomic-journals.org/content/31/6/842.full.pdf>
- Pexman, P. M., Lupker, S. J., & Hino, Y. (2002). The impact of feedback semantics in visual word recognition: Number-of-features effects in lexical decision and naming tasks. *Psychonomic Bulletin and Review*, *9*, 542–549. Retrieved from <http://pbr.psychonomic-journals.org/content/9/3/542.full.pdf>
- Ping, R. M., Dhillon, S., & Beilock, S. L. (2009). Reach for what you like: The body's role in shaping preferences. *Emotion Review*, *1*, 140–150. doi:10.1177/1754073908100439
- Prinz, W. (1997). Perception and action planning. *European Journal of Cognitive Psychology*, *9*, 129–154. doi:10.1080/713752551
- Proffitt, D. R. (2006). Embodied perception and the economy of action. *Perspectives on Psychological Science*, *1*, 110–122. doi:10.1111/j.1745-6916.2006.00008.x
- Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin*, *114*, 510–532. doi:10.1037/0033-2909.114.3.510
- Reber, R., & Schwarz, N. (1999). Effects of perceptual fluency on judgments of truth. *Consciousness and Cognition*, *8*, 338–342. doi:10.1006/ccog.1999.0386
- Reber, R., Winkielman, P., & Schwarz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science*, *9*, 45–48. doi:10.1111/1467-9280.00008
- Regenberg, N. F. E., Häfner, M., & Semin, G. R. (2010a). *Can't read it, must eat it: Processing fluency and self-control*. Manuscript in preparation.
- Regenberg, N. F. E., Häfner, M., & Semin, G. R. (2010b). *Getting in touch with your senses: Costs and benefits of multimodal processing*. Manuscript in preparation.
- Regenberg, N. F. E., Häfner, M., & Semin, G. R. (in press). The groove move: Action affordances produce fluency and positive affect. *Ex-*

perimental Psychology.

- Regenberg, N. F. E., & Semin, G. R. (2010). *When picking sides becomes physical: Action affordances produce fluency and positive affect.* Manuscript in preparation.
- Schwarz, N. (2002). Situated cognition and the wisdom of feeling: Cognitive tuning. In L. Feldman-Barrett & P. Salovey (Eds.), *The wisdom of feeling* (pp. 144–166). Guilford Press, New York.
- Schwarz, N. (2004). Metacognitive experiences in consumer judgment and decision making. *Journal of Consumer Psychology, 14*, 332–348. doi:10.1207/s15327663jcp1404_2
- Schwarz, N., & Clore, G. (1996). Feelings and phenomenal experiences. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology: Handbook of basic principles* (pp. 433–465). Guilford Press, New York.
- Schwarz, N., Song, H., & Xu, J. (2008). When thinking is difficult: Metacognitive experiences as information. In M. Wänke (Ed.), *The social psychology of consumer behavior* (pp. 201–223). Psychology Press, New York.
- Searle, J. R. (1980). Minds, brains and programs. *Behavioral and Brain Sciences, 3*, 417–424. doi:10.1017/S0140525X00005756
- Sebanz, N., & Knoblich, G. (2009). Jumping on the ecological bandwagon? Mind the gap! *European Journal of Social Psychology, 39*, 1230–1233. doi:10.1002/ejsp.688
- Sebanz, N., Knoblich, G., & Prinz, W. (2003). Representing others' actions: Just like one's own? *Cognition, 88*, 1230–1233. doi:10.1016/S0010-0277(03)00043-X
- Shah, A. K., & Oppenheimer, D. M. (2007). Easy does it: The role of fluency in cue weighting. *Judgment and Decision Making, 2*, 371–379. Retrieved from <http://journal.sjdm.org/jdm7730.pdf>
- Smith, E. E., Adams, N., & Schorr, D. (1978). Fact retrieval and the paradox of interference. *Cognitive Psychology, 10*, 438–464. doi:10.1016/0010-0285(78)90007-5
- Smith, E. R. (1996). What do connectionism and social psychology offer each other? *Journal of Personality and Social Psychology, 70*, 893–912. doi:10.1037/0022-3514.70.5.893

- Smith, E. R., & DeCoster, J. (1998). Knowledge acquisition, accessibility, and use in person perception and stereotyping: Simulation with a recurrent connectionist network. *Journal of Personality and Social Psychology, 74*, 21–35. doi:10.1037/0022-3514.74.1.21
- Smith, E. R., & Semin, G. R. (2004). Socially situated cognition: Cognition in its social context. *Advances in Experimental Social Psychology, 36*, 53–117. doi:10.1016/S0065-2601(04)36002-8
- Son, L. K., & Metcalfe, J. (2000). Metacognitive and control strategies in study-time allocation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 26*, 204–221. doi:10.1037/0278-7393.26.1.204
- Song, H., & Schwarz, N. (2008a). Fluency and the detection of misleading questions: Low processing fluency attenuates the Moses illusion. *Social Cognition, 26*, 791–799. doi:10.1521/soco.2008.26.6.791
- Song, H., & Schwarz, N. (2008b). If it's hard to read, it's hard to do: Processing fluency affects effort prediction and motivation. *Psychological Science, 19*, 986–988. doi:10.1111/j.1467-9280.2008.02189.x
- Song, H., & Schwarz, N. (2010). If it's easy to read, it's easy to do, pretty, good, and true. *The Psychologist, 23*, 108–111. Retrieved from http://www.thepsychologist.org.uk/archive/archive_home.cfm?volumeID=23&editionID=185&ArticleID=1629
- Spence, C., Nicholls, M. E. R., & Driver, J. (2000). The cost of expecting events in the wrong sensory modality. *Perception & Psychophysics, 63*, 330–336. Retrieved from <http://app.psychonomic-journals.org/content/63/2/330.full.pdf>
- Stefanucci, J. K., Proffitt, D. R., Clore, G. L., & Parekh, N. (2008). Skating down a steeper slope: Fear influences the perception of geographical slant. *Perception, 37*, 321–323. doi:10.1068/p5796
- Stefanucci, J. K., & Storbeck, J. (2009). Don't look down: Emotional arousal elevates height perception. *Journal of Experimental Psychology: General, 138*, 131–145. doi:10.1037/a0014797
- Stoffregen, T. A. (2003). Affordances as properties of the animal-environment system. *Ecological Psychology, 15*, 115–134. doi:10.1207/S15326969ECO1502_2

- Symes, E., Ellis, R., & Tucker, M. (2007). Visual object affordances: Object orientation. *Acta Psychologica*, *124*, 238–255. doi:10.1016/j.actpsy.2006.03.005
- Tucker, M., & Ellis, R. (1998). On the relations between seen objects and components of potential actions. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 830–846. doi:10.1037/0096-1523.24.3.830
- Tucker, M., & Ellis, R. (2001). The potentiation of grasp types during visual object categorization. *Visual Cognition*, *8*, 769–800. doi:10.1080/13506280042000144
- Tucker, M., & Ellis, R. (2004). Action priming by briefly presented objects. *Acta Psychologica*, *116*, 185–203. doi:10.1016/j.actpsy.2004.01.004
- Van Dantzig, S., Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2008). Perceptual processing affects conceptual processing. *Cognitive Science*, *32*, 579–590. doi:10.1080/03640210802035365
- Vermeulen, N., Corneille, O., & Niedenthal, P. M. (2008). Sensory load incurs conceptual processing costs. *Cognition*, *109*, 287–294. doi:10.1016/j.cognition.2008.09.004
- Warren, W. H. (1984). Perceiving affordances: visual guidance of stair climbing. *Journal of Experimental Psychology: Human Perception and Performance*, *10*, 683–703. doi:10.1037/0096-1523.10.5.683
- Whittlesea, B. W. A. (1993). Illusions of familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*, 1235–1253. doi:10.1037/0278-7393.19.6.123
- Whittlesea, B. W. A. (2004). The perception of integrality: Remembering through the validation of expectation. *Experimental Psychology: Learning, Memory and Cognition*, *30*, 891–908. doi:10.1037/0278-7393.30.4.891
- Whittlesea, B. W. A., Jacoby, L. L., & Girard, K. (1990). Illusions of immediate memory: Evidence of an attributional basis for feelings of familiarity and perceptual quality. *Journal of Memory and Language*, *29*, 716–732. doi: 10.1016/0749-596X(90)90045-2
- Whittlesea, B. W. A., & Williams, L. D. (1998). Why do strangers seem familiar, but friends do not? A discrepancy-attribution ac-

- count of feelings of familiarity. *Acta Psychologica*, *98*, 141–165. doi:10.1016/S0001-6918(97)00040-1
- Whittlesea, B. W. A., & Williams, L. D. (2000). The source of feelings of familiarity: The discrepancy-attribution hypothesis. *Journal of Experimental Psychology: Learning, Memory and Behavior*, *26*, 547–565. doi:10.1037/0278-7393.26.3.547
- Willems, R. M., Hagoort, P., & Casasanto, D. (2010). Body-specific representation of action verbs: Neural evidence from right- and left-handers. *Psychological Science*, *21*, 67–74. doi:10.1177/0956797609354072
- Willems, S., & Linden, M. Van der. (2006). Mere exposure effect: A consequence of direct and indirect fluency-preference links. *Consciousness and Cognition*, *15*, 323–341. doi:10.1016/j.concog.2005.06.008
- Winkielman, P., & Cacioppo, J. T. (2001). Mind at ease puts a smile on the face: Psychophysiological evidence that processing facilitation elicits positive affect. *Journal of Personality and Social Psychology*, *81*, 989–1000. doi:10.1037/0022-3514.81.6.989
- Winkielman, P., Schwarz, N., Fazendeiro, T. A., & Reber, R. (2003). The hedonic marking of processing fluency: implications for evaluative judgment. In J. Musch & K. C. Klauer (Eds.), *The psychology of evaluation: Affective processes in cognition and emotion* (pp. 189–217). Lawrence Erlbaum, Mahwah, NJ.
- Winkielman, P., Schwarz, N., & Nowak, A. (2002). Affect and processing dynamics: Perceptual fluency enhances evaluations. In S. Moore & M. Oaksford (Eds.), *Emotional cognition. from brain to behavior* (pp. 111–135). John Benjamins Publishing Company, Amsterdam/Philadelphia.
- Witt, J. K., & Proffitt, D. R. (2008). Action-specific influences on distance perception: A role for motor simulation. *Journal of Experimental Psychology: Human Perception and Performance*, *34*, 1479–1492. doi:10.1037/a0010781
- Witt, J. K., Proffitt, D. R., & Epstein, W. (2004). Perceiving distance: A role of effort and intent. *Perception*, *33*, 570–590. doi:10.1068/p5090

- Witt, J. K., Proffitt, D. R., & Epstein, W. (2005). Tool use affects perceived distance, but only when you intend to use it. *Journal of Experimental Psychology: Human Perception and Performance*, *31*, 880–888. doi:10.1037/0096-1523.31.5.880
- Yeh, W., & Barsalou, L. W. (2006). The situated nature of concepts. *American Journal of Psychology*, *119*, 349–384. Retrieved from <http://www.jstor.org/pss/20445349>
- Zajonc, R. B. (1968). Attitudinal effects of mere exposure. *Journal of Personality and Social Psychology*, *9*, 1–27. doi:10.1037/h0025848
- Zwaan, R. A., Madden, C. J., Yaxley, R. H., & Aveyard, M. E. (2004). Moving words: Dynamic representations in language comprehension. *Cognitive Science*, *28*, 611–619. doi:10.1016/j.cogsci.2004.03.004
- Zwaan, R. A., Stanfield, R. A., & Yaxley, R. H. (2002). Language comprehenders mentally represent the shape of objects. *Psychological Science*, *13*, 168–171. doi:10.1111/1467-9280.00430
- Zwaan, R. A., & Taylor, L. J. (2006). Seeing, acting, understanding: Motor resonance in language comprehension. *Journal of Experimental Psychology: General*, *135*, 1–11. doi:10.1037/0096-3445.135.1.1

Appendix A

List1		List2	
Dutch	English	Dutch	English
<i>Auditory Properties</i>			
blokfluit klinkt hoog	a recorder sounds high pitched	een brommer ronkt	a moped drones
een schildpad knerpt	a turtle crunches	een radiator suist	a radiator sings
een fietsbel rinkelt	a bicycle bell rings	een kerkorgel galmt	a church organ resounds
een supporter joelt	a supporter yells	een baby brabbelt	a baby babbles
een krekelt tjiirpt	a cricket chirps	een saxofoon schalt	a saxophone screams
een kat miauwt	a cat meows	een paard hinnikt	a horse whinnies
een trein dendert	a train rumbles	een sirene loeit	a siren wails
een hond blaft	a dog barks	een autoband piept	a tire squeals
een stationshal is rumoerig	a station's concourse is noisy	een tram knarst	a tram grinds
een vuur knettert	a fire crackles	spoorbomen rinkelen	a crossing barrier tinkles
een triangel tinkelt	a triangle tinkles	een zangeres zingt	a soprano sings
pannen kletteren	pots clatter	onweer dondert	a thunderstorm roars
een typemachine ratelt	a typewriter rattles	een vlieg zoemt	a fly buzzes
naaldhakken tikken	high heels tick	kreupelhout kraakt	a thicket crackles
een vliegtuig is luidruchtig	an airplane is loud	een vrachtwagen toetert	a truck honks
herfstbladeren ritselen	leaves rustle	een wekker tikt	an alarm clock ticks
<i>Tactile properties</i>			
een dwell is klam	a mop is damp	badwater is lauwwarm	bathwater is lukewarm
een kiezel is hard	a pebble is hard	een pyjama is zacht	pyjamas are soft
een grot is kil	a cave is chilly	een gloeilamp is loeiheet	a light bulb is extremely hot

List1

List2

Dutch	English	Dutch	English
een paard is fijnharig	a horse has fine hairs	corduroy is geribbeld	corduroy is ribbed
een knikker is keihard	a marble is hard as stone	een gum is stroef	a gum eraser is stiff
een spons is vochtig	a sponge is humid	een handdoek is droog	a towel is dry
een mier kriebelt	an ant tickles	een muggenbult jeukt	a mosquito bite itches
fluweel is zacht	velvet is soft	een douche is nat	a shower is wet
een kraan is loeiheet	a faucet is extremely hot	een muntje is hard	a coin is hard
schors is ruw	tree bark is rough	zand schuurt	sand grinds
een sneeuwbal is koud	a snowball is cold	een sjaal kriebelt	a shawl itches
jodium prikt	iodine stings	regen is fris	rain is fresh
een strijkijzer is heet	an iron is hot	een snoepje is plakkerig	a piece of candy is sticky
een waterval is koel	a waterfall is cool	hagel is koud	hail is cold
een theepot is warm	a teapot is warm	een suikerspin is kleverig	cotton candy is sticky
een veertje kietelt	a feather tickles	een tosti is warm	a grilled cheese sandwich is warm
<i>Visual Properties</i>			
boter is gelig	butter is yellowish	broccoli is groen	broccoli is green
asfalt is dof	asphalt pavement is dull	een lieveheersbeestje is gestippeld	a lady-bird has dots
chocola is donkerbruin	chocolate is brown	een aubergine is donkerpaars	an eggplant is deep purple
de hemel is blauw	the sky is blue	een paprika is glanzend	a pepper is shiny
een binnenband is matzwart	an inner tube is matte black	een cassettebandje is zwart	a cassette tape is black
een mandarijn is oranje	a tangerine is orange	een druif is lichtgroen	a grape is light green
een diamant glinstert	a diamond sparkles	een eekhoorn is roodbruin	a red squirrel is reddish brown

List1		List2	
Dutch	English	Dutch	English
een baksteen is rood	a brick is red	een theedoek is geruit	a dish towel is checkered
een ijsklontje is doorzichtig	an ice cube is transparent	een kelder is donker	a basement is dark
spinazie is donkergroen	spinach is dark green	mayonaise is lichtgeel	mayonaise is light yellow
een kwal is doorschijnend	a jellyfish is translucent	een luipaard is gespikkeld	a leopard is spotted
honing is goudgeel	honey is golden yellow	ham is roze	ham is pink
een orka is zwart-wit	a killer whale is black and white	een pepermuntje is wit	peppermint candy is white
een wesp is gestreept	a wasp is striped	een zwembad is azuurblauw	a pool is azure blue
een schaakbord is geblokt	a chessboard is checkered	een scheermesje is zilver	a razorblade is silver
een walnoot is bruin	a walnut is brown	een tennisbal is geel	a tennis ball is yellow
<i>Other Properties</i>			
een citroen is zuur	a lemon is sour	een grapefruit is bitterzoet	a grapefruit is bitter-sweet
een parfum geurt	perfume gives scent	een peen is zoetig	a carrot is sweetish
zeep is geparfumeerd	soap is scented	een stroopwafel is zoet	a syrup waffle is sweet
chips zijn zout	potato chips are salty	peper is scherp	pepper is sharp

List1		List2	
Dutch	English	Dutch	English
een pil is geurloos	a pill is odorless	een perzik is geurig	a peach is fragrant
een peperoni is pikant	pepperoni is spicy	zweet stinkt	sweat smells

Table 7.1: Stimuli of Experiment 1: Two Lists of Auditory, Tactile, and Visual Concept-Property Pairs Were Administered in a Random Order in a Property-Verification Task.

Note: English translations do not always perfectly correspond in meaning to the Dutch stimuli.

Appendix B

concept	properties		M(SD)		difference test
	single-modality	multi-modality	single-modality	multi-modality	
theedoek (dish towel)	uitwringen, af- drogen, wrijven (to wring, to dry, to rub)	geruit, wrijven, vochtig (checked, rub, humid)	val: typ:	val: typ:	$t(21) = .20, p = .847$ $t(22) = .77, p = .453$
aubergine (eggplant)	paars, glanzend, donker (purple, shiny, dark)	donker, opeten, glad (dark, to eat, smooth)	val: typ:	val: typ:	$t(21) = .00, p = 1.000$ $t(22) = .96, p = .348$
vuur (fire)	geel, rood, flikkert (yellow, red, flickers)	rood, aanpoken, heet (red, poke, hot)	val: typ:	val: typ:	$t(21) = .10, p = .921$ $t(22) = -1.65, p = .114$
trein (train)	denderend, tsjoekend, luid (thundering, choo-chooing, loud)	piepend, uit- stappen, met- alig (squeaking, exit, metallic)	val: typ:	val: typ:	$t(25) = -.97, p = .342$ $t(20) = .78, p = .444$
paard (horse)	hinnikend, hoe- fletterend, snuivend (whinnying, clattering hoofs, snorting)	zadelen, fijn- horig, strolucht (to saddle up, fine haired, scent of hay)	val: typ:	val: typ:	$t(25) = -.09, p = .928$ $t(20) = 1.19, p = .249$

concept	properties		M(SD)		difference test
	single-modality	multi-modality	single-modality	multi-modality	
radiator	metallig, heet, geribbeld	wit, heet, borrelend	0.50 (1.12)	0.39 (1.17)	$t(25) = .57, p = .575$
(radiator)	(<i>metallic, hot, ribbed</i>)	(<i>white, hot, gurgling</i>)	1.27 (1.20)	1.00 (1.04)	$t(20) = 1.36, p = .190$
verf	vloeibaar, plakkerig, nat	chemisch, nat, doorroeren	0.09 (1.35)	0.00 (1.48)	$t(21) = .37, p = .714$
(paint)	(<i>liquid, sticky, wet</i>)	(<i>chemical, wet, to stir</i>)	1.33 (1.27)	1.47 (1.32)	$t(19) = -.58, p = .571$
peen	schrappen, schillen, raspen	langwerpig, schoonmaken, hard	0.12 (2.08)	0.04 (1.43)	$t(21) = .23, p = .818$
(carrot)	(<i>to scrape, to peel, to grate</i>)	(<i>oblong, clean, hard</i>)	0.38 (1.39)	0.83 (1.05)	$t(19) = -1.39, p = .180$
grapefruit	peilen, snijden, uitpeelen	snijden, rozet, bitterzoet	0.14 (1.22)	0.27 (1.29)	$t(21) = -.89, p = .383$
(grapefruit)	(<i>to peel, to cut, to spoon out</i>)	(<i>to cut, pink, bittersweet</i>)	0.47 (1.24)	0.57 (1.46)	$t(19) = -.36, p = .722$
handvat	loslaten, grijpen, aanpakken	grijpen, hard, geurloos	0.42 (1.10)	0.35 (1.23)	$t(21) = .36, p = .725$
(handle)	(<i>to let go, to grab, to grip</i>)	(<i>to grab, hard, odorless</i>)	1.03 (1.34)	1.05 (1.29)	$t(19) = -.06, p = .951$
gloeilamp	heet, glad, hard	wit, draaien, heet	0.12 (1.35)	0.29 (1.27)	$t(22) = -.80, p = .433$
(light bulb)	(<i>hot, smooth, hard</i>)	(<i>white, screw, hot</i>)	1.09 (1.03)	1.09 (0.68)	$t(21) = .00, p = 1.000$

concept	properties		M(SD)		difference test
	single-modality	multi-modality	single-modality	multi-modality	
boomstam (tree trunk)	ruw, gegroefd (rough, grooved)	hard, bruin, ribbelig (brown, ribbed)	hakken, val: typ:	0.23 (1.45) 0.13 (1.59) 1.47 (1.11)	$t(22) = .41, p = .687$ $t(21) = .53, p = .599$

Table 7.2: Stimuli of experiment 2: Concept words paired with three properties from a single modality or from three different modalities with mean valence (val) and typicality (typ) ratings. English translation in parentheses. Note: The table provides pretest ratings for valence (val) and typicality (typ); each assessed on a scale from -3 = "negative"/"not typical" to 3 = "positive"/"typical" and difference tests for each combination of a concept with the three properties from one condition. English translations do not always perfectly correspond in meaning to the Dutch stimuli

Summary

In our daily lives, we are often not only influenced by what we are thinking but also by how easy these thoughts come to mind or how easy new information can be processed. There is ample research to demonstrate the effects of such processing ease – the so called processing fluency. For example, we like things better the more often we see them (because we can process them more easily) and when our cognitive processes go smoothly, it makes us feel good.

The current dissertation addresses different aspects of such processing fluency. Whereas previous research has focused on fluency experiences based on abstract information processing (“thinking”), the research underlying this dissertation explored whether fluency, its affective consequences can also be caused by actual or simulated *physical* interactions with objects (“doing”). The underlying hypothesis is therefore that smooth and effortless interactions should trigger feelings of fluency and generally a positive affective response.

Chapter 2 demonstrates that fluency can indeed be grounded in the motor system. In two laboratory experiments, participants had to act on objects that appeared on a computer screen. These actions were either compatible with the objects’ implied orientation, such as a right-hand action on a cup whose handle was oriented toward the right, or they were not compatible, such as a right-hand action when the cup’s handle was oriented to the left. The results show that after the easier,

compatible actions, participants experienced more positive affect and a feeling of fluency than after the more difficult, incompatible actions.

Building on these results, Chapter 3 poses the question whether the mere anticipation of motor fluency is enough to drive an individual's preferences, such that the easiest course of action is preferred. Participants in two experiments imagined that they were to play table-tennis and had to pick a side to play at. Participants playing with their right hand preferred the right side, whereas participants playing with their left hand preferred the left side. This occurred for participants' natural handedness and for an experimental manipulation of the play-hand. In other words, people preferred the side that was most accessible and easy to go to – although this factor should be irrelevant as both sides were in fact equal. These results suggest that people use such physical cues to make preference judgments and that these cues differ as individuals differ in their physical makeup, such as being right- or left-handed, or as the situational constraints change.

Chapter 2 and 3 therefore demonstrate that physical interactions – or even the mere anticipation of such interactions can give rise to fluency effects. However, recent theories of cognition propose that also more abstract processes, such as language comprehension, involve the motor system. Reading a sentence like “*The lemon tastes sour.*” implies no real, physical interaction with an object. Nevertheless, perceptual theories of knowledge propose that even the way we understand language relies on perceptual variables. Accordingly, we derive meaning from concepts by (partially) re-enacting relevant experiences we have had with them. For example, when offered a glass of lemon juice, one might particularly think about how lemons taste sour. However, while arranging a lemon with other fruits to prepare a nice fruit basket, the current representation of the concept “lemon” might include its shape (“where would the lemon fit”) or its color (“it might look nicer next to a red apple than next to a yellow banana”) rather than its taste. The research in Chapter 4 therefore addresses whether conceptual thought can give rise to fluency experiences. Assuming that concept represen-

tations indeed hinge upon the re-enactment of perceptual variables, we hypothesized that the more *different* sensory modalities (such as taste, vision, or touch) are involved in the representation of a concept, the easier it should be to derive its meaning. Experiencing this processing ease should then again trigger fluency effects. The results of two experiments support this prediction: Participants experienced positive affect after processing a series of words from a multitude of sensory modalities as compared to a single sensory modality and they rated concepts as more positive when these had been paired with attributes from different sensory modalities as compared to when they had been paired with attributes from a single modality.

Finally, the research in Chapter 5 more generally explores the functional value of processing fluency. The underlying assumption is that cognitive processes aren't a random phenomenon of the mind, but that any cognitive process serves action – or at least its preparation. Therefore, fluency in all its variants is functional because it shows us that things are going the way they should. They feel good. However, from this perspective, disfluency should be particularly relevant for us because it signals us that things are *not* going as they should. Disfluent processes feel “wrong” or even bad. Therefore, whenever we experience disfluency, we should (want to) engage in self-regulatory acts to change something in the situation at hand. Two experiments in Chapter 5 explore this hypothesis. The results support the view that fluency experiences are in fact related to self-regulation.

Overall, the current dissertation discusses experimental research exploring different antecedents and consequences of processing fluency, involving sensorimotor fluency, anticipated action fluency, conceptual fluency, and perceptual fluency.

Samenvatting

Zinvol Reageren

Elke dag zijn we onder invloed van onze gedachten. Hierbij is het niet alleen van belang waarover we nadenken, maar ook hoe makkelijk ons zulke denkprocessen van de hand gaan of hoe makkelijk we nieuwe informatie kunnen verwerken. Talloze onderzoeksresultaten tonen aan dat het gemak van onze cognitieve processen – de zogenaamde fluency – vergaande gevolgen kan hebben. Bijvoorbeeld houden we meer van dingen die we vaak zien (en die daarom makkelijk te verwerken of te begrijpen zijn) en als we cognitieve processen goed beheersen, voelen we ons zelf beter.

In dit proefschrift werden verschillende aspecten van fluency onderzocht. Terwijl eerder onderzoek focust op fluency ervaringen op basis van abstracte informatieverwerking (“denken”), is dit onderzoek gericht op de vraag of fluency (en de daarmee verbonden stemmingswisseling) veroorzaakt kan zijn door echte of gesimuleerde belichaamde interacties (“doen”).

De fundamentele hypothese van dit onderzoek is dat interacties die vloeiend, soepel en moeiteloos verlopen een gevoel van fluency veroorzaken en in het algemeen een positieve affectieve reactie opwekken.

Hoofdstuk 2 toont aan dat fluency ervaringen wel degelijk in het motorisch systeem kunnen baseren. Proefpersonen in twee laboor experimenten moesten reageren op objecten die op een computerbeeldscherm verschenen. De vereisten bewegingen waren óf compatibel met de oriëntatie van deze objecten, bijvoorbeeld een beweging met de rechterhand naar een koffiekop met het oortje naar rechts, of de bewegingen waren incompatibel met de oriëntatie van de objecten, bijvoorbeeld een beweging met de rechterhand naar een koffiekop met het oortje naar links. Uit de resultaten van deze experimenten blijkt dat de proefpersonen zich positiever voelen na de makkelijkere, compatibele acties. De proefpersonen gaven ook aan een fluency gevoel te ervaren na deze acties.

Gebaseerd op deze resultaten is Hoofdstuk 3 gericht op de vraag of alleen de verwachting van een makkelijke beweging tegenover een moeizame beweging al voldoende is om de voorkeur voor bepaalde acties te beïnvloeden. De hypothese was dat men een voorkeur zou moeten hebben voor de actie die de minste hoeveelheid moeite zou vereisen. Proefpersonen in twee experimenten verbeelden zich dat ze tafeltennis zouden gaan spelen en dat ze een kant moesten kiezen waar ze wilden spelen. Proefpersonen die met hun rechterhand gingen spelen hadden een voorkeur voor de rechterkant en proefpersonen die met hun linkerhand gingen spelen hadden een voorkeur voor de linkerkant. Dit resultaat werd zowel aangetoond bij de dominante hand van de proefpersonen (dus of ze normaliter ook met de rechter- of linkerhand zouden spelen), maar ook als de hand waarmee ze zouden spelen experimenteel gemanipuleerd was. Met andere woorden, de proefpersonen hadden een voorkeur voor de kant die het meest toegankelijk was, waar ze op een makkelijke manier naartoe zouden kunnen gaan – terwijl deze factor irrelevant was omdat beide kanten eigenlijk gelijk waren. Deze bevindingen duiden aan dat men belichaamde signalen gebruikt om een voorkeurbeslissing te nemen en dat deze signalen verschillen voor mensen als deze een andere fysische opmaak hebben, zoals het rechts- of linkshandig te zijn. Bovenal hangen deze signalen kennelijk af van de omstandigheden of situatie van het moment.

In het geheel wordt in de Hoofdstukken 2 en 3 aangetoond dat lichaamsde interacties – of zelfs alleen maar de verwachting van zulke interacties – fluency effecten kunnen opwekken. Echter stellen recente theorieën van cognitie dat zelfs meer abstracte processen zoals taalbegrip het motorische systeem involveren. Er zijn geen echte, fysieke interacties betrokken als je een zin als “*De limoen smaakt zuur.*” leest. Toch stellen perceptuele theorieën van cognitie dat de manier waarop we taal begrijpen gebaseerd is op waarnemingsvariabelen. Volgens deze theorieën begrijpen wij de betekenis van concepten door relevante ervaringen met deze concepten (gedeeltelijk) te reconstrueren. Bijvoorbeeld, als iemand ons een glas limoen sap aanbiedt, denken we misschien eraan dat limoenen zuur smaken. Maar als we een limoen samen met anderen stukken fruit in een schaal neerzetten, houdt onze representatie van het concept “limoen” misschien meer zijn vorm in (“waar zou hij goed passen”), of zijn kleur (“het zou beter uitzien naast een rode appel dan naast een gele banaan”), dan de smaak. In Hoofdstuk 4 wordt de vraag gesteld of zulke denkprocessen tot fluency ervaringen kunnen leiden. Gebaseerd op de aanname dat de aanwezigheid van concepten inderdaad variabelen in de waarneming kent, wordt gesuggereerd dat het eenvoudiger zou moeten zijn om de betekenis van concepten te begrijpen als deze zijn gekoppeld aan ervaringen van meerdere zintuigen (bijvoorbeeld smaak, het gezichtsvermogen, en de tastzin). De ervaring van dit gemak in de verwerking van concepten zou dan weer fluency effecten moeten induceren. De bevindingen uit twee experimenten ondersteunen deze hypothesen: Proefpersonen ervoeren een positief gevoel nadat ze zinnen hebben verwerkt die aan verschillende zintuigen waren gekoppeld – in vergelijking met zinnen die aan één zintuig waren gekoppeld. Bovendien hebben de proefpersonen concepten als positiever geëvalueerd als deze met eigenschappen van verschillende zintuigen waren geassocieerd dan als deze met eigenschappen vanuit een enkel zintuig waren geassocieerd.

Tot slot wordt in Hoofdstuk 5 onderzoek voorgesteld over de algemene functie van fluency ervaringen. Gebaseerd op de aanname dat cognitieve processen geen willekeurig fenomeen van de geest zijn, maar dat ze in feite ertoe dienen om te kunnen (re)ageren – of om acties voor

te bereiden, wordt verondersteld dat fluency in alle varianten functioneel is omdat het aangeeft dat de dingen verlopen zoals ze moeten. “Het voelt goed”. Vanuit dit perspectief zou de ervaring van disfluency vooral relevant zijn omdat het betekent dat dingen niet zo lopen als gepland of verwacht. Het voelt “verkeerd” of zelfs slecht. Daarom zou de ervaring van disfluency altijd een aanleiding zou moeten zijn om zelfregulatie te beoefenen en de situatie te veranderen. Twee experimenten in Hoofdstuk 5 onderzoeken deze hypothese. De resultaten ondersteunen het idee dat fluency ervaringen gerelateerd zijn aan zelfregulatie.

In totaal behandelt het voorliggende proefschrift experimenteel onderzoek naar verschillende voorwaarden en gevolgen van fluency, onder andere belichaamde fluency ervaringen, verwachte fluency, conceptuele fluency, en perceptuele fluency.

Zusammenfassung

Sinnvoll Agieren

Im Alltag werden wir ständig durch unsere Gedanken beeinflusst. Überraschenderweise spielt es hierbei nicht allein eine Rolle, was wir denken oder worüber wir nachdenken, sondern auch, wie leicht wir diese Gedanken formen und wie einfach wir neue Informationen verarbeiten können. Zahlreiche Forschungsergebnisse demonstrieren die weitreichenden Effekte solcher Verarbeitungsleichtigkeit, der sogenannten *Verarbeitungsflüssigkeit*. Beispielsweise mögen wir Dinge mehr, je häufiger wir sie sehen (da sie einfacher zu verarbeiten oder begreifen sind) und wenn unsere kognitiven Prozesse glatt verlaufen, fühlen wir uns gut.

Die vorliegende Dissertation untersucht verschiedene Aspekte dieser Verarbeitungsflüssigkeit. Während sich die bisherige Forschung zur Erfahrung von Verarbeitungsflüssigkeit auf abstrakte Informationsverarbeitungsprozesse konzentriert (“Denken”), erforscht die vorliegende Arbeit ob Verarbeitungsflüssigkeit und die damit verbundenen affektiven Folgen auch durch körperliche Interaktionen hervorgerufen werden können (“Tun”). Dabei geht es um tatsächliche oder simulierte Interaktionen. Die zugrunde liegende Hypothese besagt, dass mühelos und glatt ablaufende Interaktionen ein Gefühl der Verarbeitungsflüssigkeit und im allgemeinen eine positive affektive Reaktion hervorrufen.

Kapitel 2 zeigt, dass Verarbeitungsflüssigkeit tatsächlich im motorischen System verankert sein kann. In zwei Laborexperimenten mussten Probanden mit Gegenständen interagieren, die auf einem Bildschirm angezeigt wurden. Die erforderlichen Handlungen waren entweder kompatibel mit der Ausrichtung des Gegenstandes, wie zum Beispiel mit der rechten Hand nach einer Tasse zu greifen, deren Henkel nach rechts zeigt, oder die Handlungen waren inkompatibel mit der Ausrichtung der Tasse, beispielsweise wenn man mit der rechten Hand nach einer Tasse greifen muss, deren Henkel nach links zeigt. Die Ergebnisse zeigen, dass die Versuchsteilnehmer sich nach den einfacheren, kompatiblen Handlungen positiver fühlten und ein Gefühl der Verarbeitungsflüssigkeit erfahren.

Aufgrund dieser Ergebnisse befasst sich Kapitel 3 mit der Frage, ob die bloße Erwartung motorischer Verarbeitungsflüssigkeit ausreicht, um die Vorlieben einer Person zu beeinflussen, sodass die einfachste Handlung bevorzugt wird. In zwei Experimenten stellten sich Probanden vor, dass sie Tischtennis spielen würden und erst wählen müssten, auf welcher Seite sie spielen wollen. Probanden, die mit ihrer rechten Hand spielten, bevorzugten überwiegend die rechte Seite des Tischtennistisches, während Probanden, die mit der linken Hand spielten, die linke Seite bevorzugten. Diese Ergebnisse wurden sowohl für die dominante Hand der Probanden gefunden (ob sie regulär mit der rechten oder linken Hand spielen würden) also auch für eine experimentelle Manipulation der Spielhand. Mit anderen Worten bevorzugten die Probanden jeweils die Seite, die am zugänglichsten war, zu der sie am einfachsten hingehen konnten – obwohl dieser Faktor eigentlich irrelevant war, da beide Seiten gleich waren. Dieser Befund lässt darauf schließen, dass man körperliche Signale benutzt um Präferenzurteile zu fällen und dass diese Signale sich je nach Körperbau (beispielsweise für Links- und Rechtshänder) oder Situation unterscheiden können.

Die Kapitel 2 und 3 zeigen daher, dass körperliche Interaktionen – und sogar die bloße Erwartung solcher Interaktionen – ein Gefühl der Verarbeitungsflüssigkeit hervorrufen können. Allerdings schlagen neuere

Kognitionstheorien vor, dass das motorische System auch bei abstrakteren Prozesse wie etwa dem Verständnis von Sprache eine Rolle spielt. Wenn man eine Satz wie *“Die Zitrone schmeckt sauer.”* liest, impliziert dies keine echte körperliche Interaktion mit einer Zitrone. Trotzdem gehen wahrnehmungsbasierte Kognitionstheorien davon aus, dass die Art und Weise wie wir Sprache verstehen von Wahrnehmungsvariablen abhängt. Demzufolge leiten wir die Bedeutung eines Konzeptes ab, indem wir relevante Erfahrungen mit dem Konzept (teilweise) rekonstruieren. Zum Beispiel, wenn uns jemand ein Glas Zitronensaft anbietet, denken wir besonders daran, dass Zitronen sauer schmecken. Wenn wir allerdings Zitronen mit anderen Früchten in einer Obstschale arrangieren, beinhaltet unsere Repräsentation des Konzepts *“Zitrone”* vielleicht eher ihre Form (*“wo würde die Zitrone hinpassen”*) oder ihre Farbe (*“sie würde neben dem roten Apfel besser aussehen als neben einer gelben Banane”*) statt ihres Geschmacks. Die Forschung, die in Kapitel 4 beschrieben ist, befasst sich daher mit der Frage, ob auch konzeptionelles Denken Gefühle der Verarbeitungsflüssigkeit hervorrufen kann. Unter der Annahme, dass die Repräsentation von Konzepten tatsächlich von der Rekonstruktion von Wahrnehmungsvariablen abhängt, haben wir vorhergesagt, dass es einfacher sein sollte, die Bedeutung eines Konzeptes abzuleiten, je mehr verschiedene Sinne (wie der Geschmacksinn, der Sehsinn oder der Tastsinn) in der Repräsentation des Konzepts involviert sind. Die Erfahrung dieser Verarbeitungsleichtigkeit sollte wiederum Verarbeitungsflüssigkeitseffekte hervorrufen. Die Resultate von zwei Experimenten stützen diese Hypothesen: die Probanden erfuhren ein positives Gefühl, nachdem sie eine Reihe Sätzen bearbeitet hatten, die von einer Vielzahl verschiedener Sinne kamen im Vergleich zu der Verarbeitung von Sätzen, die mit nur einem Sinn assoziiert waren. Darüber hinaus bewerteten die Probanden Konzeptwörter als positiver, wenn diese mit Attributen aus verschiedenen Sinnen gekoppelt waren als wenn diese mit Attributen aus nur einem Sinn gekoppelt waren.

Die Forschung in Kapitel 5 sondiert schließlich die Funktion von Verarbeitungsflüssigkeit im Allgemeinen. Die zugrundeliegende Annahme ist, dass kognitive Prozesse kein zufälliges Phänomen des Geistes sind,

sondern dass jeder kognitive Prozess dazu dient, handeln zu können oder Handlungen vorzubereiten. Daher ist die Verarbeitungsflüssigkeit in all ihren Variationen funktional, weil sie uns zeigt, dass die Dinge so laufen, wie sie sollten. Es fühlt sich gut an. Andererseits, sollte das Gegenteil dieser Verarbeitungsflüssigkeit ebenso relevant für uns sein, da es uns signalisiert, dass die Dinge *nicht* so laufen, wie sie sollten. Es fühlt sich verkehrt an oder sogar schlecht. Daher sollte eine solche Erfahrung uns grundsätzlich ermutigen, Selbstkontrolle auszuüben um etwas an der momentanen Situation zu verändern. Zwei Experimente in Kapitel 5 untersuchen diese Hypothese. Die Ergebnisse unterstützen die Idee, dass es tatsächlich einen Zusammenhang gibt zwischen der Erfahrung von Verarbeitungsflüssigkeit und Prozessen der Selbstregulation.

Insgesamt beschäftigt sich die vorliegende Dissertation mit experimenteller Forschung zu verschiedenen Bedingungen und Folgen der Verarbeitungsflüssigkeit, unter anderem sensomotorischer Verarbeitungsflüssigkeit, erwarteter Handlungsflüssigkeit, konzeptioneller Verarbeitungsflüssigkeit und wahrnehmungsbasierter Verarbeitungsflüssigkeit.

On the Relevance of Significant Numbers

Experimental social psychology is a quantitative science. Of course, that means that numbers are important. However, little did I know about the actual relevance of numbers when I embarked on the project of writing a dissertation over four years ago. I learned quickly that nothing is more important than the smallest and most magical number of all: 0.05. The continuous lack of this tiny number during the first two years of this project was therefore not only cause for concern, but also triggered attempts to set a new record of producing the *largest* number possible: We tried out five different topics and conducted a total of 46 experiments involving 2992 participants. A big thanks to them!

More importantly, two special people deserve my gratitude.

Gün – Despite your constant state of being flabbergasted at my ability to produce insignificant results, you never ceased to believe that the next experiment would finally work. I admire your passion about research and your ability to produce an infinite number of research ideas. Moreover, I am grateful for the freedom to define my own path and to create my own identity as a scientist.

Micha – You had the courage to step into a project about which you knew almost nothing – other than that it wasn't going very well. I

thank you for that. I learned a lot from your insight into the practical matters of setting up an experiment and about having the right nose for what will work in the lab and what won't. (Things certainly became a lot more fluent after you joined us.)

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Curriculum Vitae

Nina Regenberg (1982) was born and raised in the Saarland, a small rural state in South-West Germany. She received her undergraduate degree in social and cognitive psychology at Jacobs University Bremen and subsequently entered the research master's programme of social psychology at VU University Amsterdam from which she graduated in 2006. During her studies, she received study scholarships from Jacobs University Bremen, the German National Academic Foundation, the German Academic Exchange Service, and a Rutgers scholarship from VU University. After her studies, Nina started working on a Ph.D. project at VU University which resulted in the current dissertation.

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