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Chapter 5

Mental States Inside Out: Switching Costs for Emotional and Non-emotional Sentences that Differ in Internal and External Focus

Mental states, such as thinking, remembering, feeling angry, happy, or dizzy, have a clear internal component. We *feel* a certain way when we are in these states. These internal experiences may be simulated when people understand conceptual references to mental states. However, mental states can also be described from an 'external' perspective, for example when referring to 'smiling'. In those cases, simulation of visible outside features may be more relevant for understanding. In a switching costs paradigm, we presented semantically unrelated sentences describing emotional and non-emotional mental states while manipulating their "internal" or "external" focus. Results show that switching costs occur when participants shift between sentences with an internal and external focus. This suggests that different forms of simulation underlie understanding these sentences. In addition, these effects occurred for both emotional and non-emotional mental states, suggesting that they are grounded in a similar way -- through the process of simulation.

This chapter is based on: Oosterwijk, Winkielman, Pecher, Zeelenberg, Rotteveel & Fischer (submitted)

Everyday language contains many words that refer to people's mental states, such as, anger, exhaustion, or recognition. How do we understand such concepts? Mental states are often accompanied by internal experiences; we may feel something when we are angry, exhausted, or experience a sense of familiarity. These internal experiences may play an important role in understanding conceptual references to mental states, and may even be partly activated when these abstract concepts are processed (Barsalou, 1999).

Grounded cognition theories suggest that conceptual understanding involves the simulation of sensory states (Barsalou, 1999; Gallese & Lakoff, 2005). Importantly, Barsalou (1999) specifically proposes that simulation underlies the representation of abstract concepts, such as 'doubt', 'love' or 'anger' (see also Barsalou, Niedenthal, Barbey & Ruppert, 2003). On this account the representation of abstract concepts involves complex, multi-modal simulations, with a central role for the simulation of introspective experiences. Furthermore, several authors recently proposed that simulation of bodily states and feeling states may be causal in understanding emotion language (Glenberg, Webster, Mouilso, Havas, & Lindeman, 2009) and the use of emotion concepts (Niedenthal, 2007). Taken together, these views suggest that simulations of internal experiences, such as affective states, interoceptive states, and states that result from active self-observation (i.e., introspection), ground conceptual representations of mental states.

Take an emotion term, such as anger. Anger is associated with certain internal sensations, such as a perception of a raise in body temperature (feeling hot). This bodily sensation may be simulated when knowledge about anger is activated (Wilkowski, Meier, Robinson, Carter & Feltman, 2009). Mental states are multimodal concepts, however, and may not only be understood through simulation of internal states. Anger, for example, is also associated with external manifestations on the face (frown) or body (clenched fists) – information that is "on the outside". A focus on external components of anger may therefore involve the simulation of relevant

perceptual features in the visual system. Thus, simulation of mental states may be different depending on the context in which the mental state is situated (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). When a mental state is described in terms of internal experiences, simulation of introspectively accessible features may be relevant to understanding. When a mental state is described in terms of external, expressive manifestations, however, simulation in the visual system may be more relevant.

The link between understanding mental states and simulation has been explored mostly through studies of emotion (Havas, Glenberg, & Rinck, 2007; Niedenthal, Winkielman, Mondillon, & Vermeulen, 2009; Oosterwijk, Rotteveel, Fischer, & Hess, 2009; Wicker, Keysers, Plailly, Royet, Gallese, & Rizzolatti, 2003; for a review see Winkielman, Niedenthal, & Oberman, 2008). Nonetheless, internal states (e.g., subjective feelings, interoceptive activity) also characterize other mental states, such as experiences of visceral states (hunger, dizziness) and states classically seen as 'cognitive' (familiarity, intuition, thinking). For instance, thinking and recalling can feel easy or difficult, as reflected in subjective ratings and physiological indices of effort (Schwarz & Clore, 2007; von Helversen, Gendolla, Winkielman, & Schmidt, 2008). In another example, some propose that interoceptive states of valence and arousal are an intrinsic part of basic processes such as perception (Barrett & Bar, 2009; Barrett & Bliss-Moreau, 2009), recognition (Winkielman & Cacioppo, 2001), and memory (Phaf & Rotteveel, 2005). In addition, Craig (2002, 2009) reviewed evidence that the insula, a brain region associated with interoception, is involved in processing of many different mental experiences, varying from basic visceral states (pain, coldness, hunger) to emotional states (disgust, anger, sadness) and cognitive states (sudden insight, feeling of knowing). All of this evidence suggests that simulation of internal states may also play an important role in the understanding of linguistic references to emotional as well as non-emotional mental states. Accordingly, we propose that the distinction between

internal and external focus can be made for both emotional and non-emotional mental terms. For instance, '*he retrieved the memory from his mind*' invokes an internal experience, whereas '*her face was pale with exhaustion*' invokes an external perspective.

In the present study we examined whether understanding sentences describing mental states via simulation of internal components can be distinguished from understanding sentences describing mental states via simulation of external components. If so, then processing sentences about mental states with different foci should result in switching costs. We further examined whether such switching effects can be obtained across emotional and cognitive domains. If so, this would suggest a similarity in the representation of emotional and cognitive content. Finally, we examined whether there are differences between emotional and non-emotional sentences in the ability to induce (prime) an internal or external focus.

Previous research has found switching costs when properties of verified concepts come from different modalities, rather than the same modality (Pecher, Zeelenberg, & Barsalou, 2003; Marques, 2006; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008; Vermeulen, Niedenthal, & Luminet, 2007). For instance, Pecher, Zeelenberg, and Barsalou demonstrated that people verify that *an apple is shiny* more quickly after verifying that *a flag is striped*, than after verifying that *an airplane is noisy*. This effect is explained by flexible simulations in the modalities relevant for verifying the different properties. For example, in order to verify that *an apple is shiny*, the conceptual system will use the visual modality to simulate seeing an apple, whereas in order to verify that *an airplane is noisy*, the conceptual system will use the auditory modality to simulate hearing an airplane. If these different modality specific features are represented by their respective sensorimotor systems, a switching cost is predicted because attention has to switch between different systems (cf. Spence, Nicholls, & Driver, 2000).

The present research investigated whether switching effects occur when

people process sentences with an internal or external focus. Instead of examining simulation in the classic sensory modalities (vision, audition, smell, taste and touch) while processing concrete concepts, we examine interoceptive and visual simulation while processing sentences describing abstract mental states. To do so, we contrasted sentences inviting simulation of internal states (internal focus) with sentences inviting visual simulation (external focus). This distinction between sentences with internal focus and external focus was tested in a pilot study. Subsequently, we presented these sentences in a switching cost experiment and predicted that processing sentences describing mental terms in the same modality should be faster than processing sentences describing mental terms that cross modalities.

Furthermore, we hypothesized that conceptual knowledge about emotional and non-emotional states relies on similar processes. Therefore, we presented sentences about emotional and non-emotional mental terms in the same switching cost experiment. If switching costs across these domains are found, this would support a counterintuitive notion that "emotional" and "cognitive" mental states are understood via similar mechanisms of representation.

Pilot

Participants

The pilot study was conducted on 51 students from the University of California, San Diego, who participated for course credit. Half of the participants rated the sentences on internal focus (n = 23), and the other half rated the sentences on external focus (n = 28).

Materials and Procedure

We created 200 sensible sentences referring to 10 emotional states (i.e., *guilt*, *shame*, *disappointment*, *sadness*, *fear*, *anger*, *disgust*, *pride*, *happiness* and *love*) and 10 non-emotional states (i.e., *meditation*, *dizziness*, *intuition*, *doubt*, *hunger*, *thinking*, *remembering*, *tired*, *puzzled* and *visualization*) and varied the internal or external focus

of these sentences. The total set consisted of the following four subsets: Fifty non-emotion sentences with internal focus (*he was famished by the end of the race*, *the phone number came back to her in a flash*), fifty non-emotion sentences with external focus (*she shook her head in doubt*, *after spinning, she lost her balance*), fifty emotion sentences with internal focus (*hot embarrassment came over her*, *being at the party filled her with happiness*), and fifty emotion sentences with external focus (*his nose wrinkled with disgust*, *she lowered her head with disappointment*). Internal and external sentences incorporated the same, previously specified, set of 10 abstract concepts to ensure that sentences with different foci did not differ in terms of the mental states they described.

Participants rated all sentences on either internal or external focus using Excel spreadsheets. Internal/external focus was introduced as "the extent to which a sentence describes internal/external aspects of an experience". For internal focus it was emphasized that internal aspects of experiences can only be observed by the person himself, whereas for external focus it was emphasized that external aspects can be observed by outsiders. Internal and external focus were rated on a scale from 1 ("no internal/external focus at all") to 5 ("very high in internal/external focus").

Results

As can be seen in Table 3, internal sentences had higher internal focus than external sentences, in both the emotion category, $t(22) = 5.43$, $p < .001$, and the non-emotion category, $t(22) = 6.44$, $p < .001$. External focus was significantly higher for external sentences compared to internal sentences, for both emotion sentences, $t(27) = 8.81$, $p < .001$, and non-emotion sentences, $t(27) = 9.52$, $p < .001$.

Table 3. Internal and External Focus Rating for the Eight Different Sentence Categories (Standard Deviations in Parentheses) in the Pilot Study.

		Sentence category	
Rating dimension	Sentence focus	Emotion	Non-emotion
Internal	Internal	4.4 (.38)	3.7 (.66)
	External	3.7 (.82)	2.8 (.62)
External	Internal	2.2 (.73)	1.8 (.61)
	External	3.7 (.59)	3.7 (.67)

In short, our pilot study established that one can successfully create emotional and non-emotional sentences that refer to the same mental states, but differ in terms of subjectively rated internal and external focus. This sets the stage for the main experiment exploring processing costs when sentences with internal and external focus are contrasted.

Main Experiment

Participants and design

In total, 169 students from the University of California, San Diego participated for course credit. The experiment had a 2x2x2 design. The first two factors were varied within participants and manipulated internal versus external focus (*target focus*) and same versus different focus (*switching*). The third factor was varied between participants and manipulated whether emotion sentences served as primes and non-emotion sentences as targets, or vice versa (*order*).

Procedure

In the main experiment we randomly combined the 200 pilot-tested sentences to form prime-target pairs. The resulting 100 experimental pairs were crossed on the

same-different dimension and the external-internal dimension, creating four groups (i.e., internal-internal, external-internal, external-external, and internal-external). Prime and target sentences were fully counterbalanced over groups and sentences in different groups were matched on length. In addition, we also fully counterbalanced the content of the prime and target sentences within the experimental pairs in terms of the mental states described in the sentences. Emotion sentences and non-emotion sentences served either as targets or primes. Half of the participants were presented with the emotion sentences as primes and the non-emotion sentences as targets, and the other half were presented with the non-emotion sentences as primes and the emotion sentences as targets.

As in previous research with sentences, participants were asked to judge sensibility (Glenberg & Kaschak, 2002). Sensible sentences were mixed with non-sensible sentences ("*the curtains were dry with fear*"). Participants made responses using the "sensible" (m) or the "non-sensible" (z) key. To balance the number of sensible and non-sensible responses, we mixed the experimental pairs with 200 filler pairs. In order to obscure the fact that the sentences were systematically paired, these fillers were combined into 50 sensible-nonsensible, 50 nonsensible-sensible, and 100 nonsensible-nonsensible filler pairs.

Participants first completed 12 practice trials, followed by 300 experimental trials. Every trial started with a fixation stimulus (*****) presented for 500 ms, followed by the prime sentence. The prime sentence was removed from the screen when the participant gave a response or after 4500 ms. After a 1000 ms inter stimulus interval, the fixation stimulus was presented again followed by the target sentence. The target sentence remained on screen until a response was made (but no longer than 4500 ms). Response times (RTs) were measured from the onset of the target sentence. Participants received feedback when they made an error ("incorrect") or responded slower than 4500 ms ("too slow").

Before data analyses, we excluded participants who made more than 20%

errors (twenty-three participants; 14%), indicating that they were not performing the task as instructed or had poor reading skills. The analyses were performed on the remaining 146 participants. It is important to note that we chose this stringent exclusion rate considering the fact that 37% of UCSD students do not speak English as their native language (http://www.ucsd.edu/explore/about/facts.html). Nonetheless, a less stringent exclusion rate of 35% errors or more (leaving out 6 participants) did not change the pattern of our results. Mean RTs were computed for each condition. RTs for trials with incorrect responses to prime or target sentence or RTs more than 3 standard deviations from the participant's mean were excluded.

Results

We predicted that participants would be faster judging subsequently presented unrelated sentences within the same focus (internal-internal or external-external focus) than across focus (internal-external or external-internal). A repeated measures ANOVA showed the expected switching effect, $F(1, 144) = 6.51$, $p = .01$, $\eta_p^2 = .04$. RTs to non-switch trials ($M = 1673$ ms) were faster than RTs to switch trials ($M = 1696$ ms). The interaction between switching (switch, no-switch) and target focus (internal, external) was not significant, $F(1, 144) < 1$, $p = .87$. This indicates that the switching effect was equally strong for targets with an internal and external focus (see Table 4).

We were also interested in whether emotional or non-emotional sentences differed in their ability to prime focus. Although numerically the switching effect was larger for non-emotional targets (31 ms) than emotional targets (16 ms), statistically the interaction between switching and the order of emotional and non-emotional sentences was not significant, $F(1, 144) < 1$, $p = .41$. In addition, there was a theoretically uninteresting main effect of target focus, $F(1, 144) = 20.74$, $p < .001$, $\eta_p^2 = .13$. RTs were faster to internal than external targets (1665 ms vs. 1704 ms). Finally, no switching cost effect was present in the error rates, $F(1, 144) = .88$, $p = .35$.

Table 4. Mean Reaction Times in Milliseconds (RT) and Percent Errors (PE) for Sensibility Judgments in No Switch and Switch Conditions (Standard Deviations in Parentheses).

Condition	RT	PE
Internal target sentence		
No switch	1654 (328)	7.12 (5.8)
Switch	1675 (327)	7.18 (5.6)
Switching cost	21	0.06
External target sentence		
No switch	1690 (355)	7.94 (6.2)
Switch	1714 (341)	7.07 (5.9)
Switching cost	24	-0.87

Discussion

The present study explored whether modality focus effects extend beyond the classic sensory-motor domains into the domain of internal and external aspects of emotional and non-emotional knowledge. The pilot study showed that we successfully created emotional and non-emotional sentences that referred to the same mental states, but differed in terms of subjectively rated internal and external focus. The main experiment demonstrated that sentences describing internal aspects of mental states were judged faster when primed with sentences with the same focus (internal) than when primed with sentences with a different focus (external). A similar switching effect was present for sentences with an external focus.

The presence of switching costs suggests that understanding internal aspects of both emotional and non-emotional states relies on a different process than understanding external aspects of emotional and non-emotional states. Hence we propose, in accordance with theories of grounded cognition (Barsalou, 1999;

Glenberg & Robertson, 2000), that internal and external sentences are understood through simulation in different systems. While external sentences may be associated with simulation in visual systems, internal sentences may be associated with simulation in systems associated with feeling states and interoception, such as the insular cortex (Craig, 2002, 2009). Consequently, the present results may be interpreted as support for an interoceptive or introspective "modality" (Barsalou, 1999). This extends previous work on switching effects that have mainly focused on the classic sensory modalities (Pecher, Zeelenberg, & Barsalou, 2003; Marques, 2006; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008; but see Vermeulen, Niedenthal, & Luminet, 2007).

Most concepts, including abstract concepts, are multi-modally represented. Take the example of anger. Anger is associated with internal states (e.g., high arousal, raised body temperature) *and* external features (e.g., clenched fists, a frowning face). As such, both internal and external simulations could underlie understanding this concept. This is consistent with our pilot study that indicated that our sentences were not exclusively internal or external. Hence, the complete simulation that accompanies sentence understanding may be multi-modal (i.e., a mix of different modalities). Nevertheless, the switching cost found in the present study suggests that within this mix of simulations, simulation in one modality is most pronounced. We propose that the internal or external focus of the presently used sentences draws attention to internal or external components of the presented concepts, and that simulation consequently occurs predominantly in the most relevant modality (see also Conell & Lynott, 2009).

The results of this study fit well with the existing literature on emotion and embodiment. Several authors propose that simulation of internal bodily states may be important in the conceptual representation of abstract mental states such as emotions (Glenberg, Webster, Mouilso, Havas, & Lindeman, 2009; Niedenthal, 2007). Our findings provide further support for this proposal and are also in line

with findings that processing conceptual knowledge of emotion activates 'internally-accessible' bodily states, as reflected for example, in electrodermal activity (Oosterwijk, Topper, Rotteveel, & Fischer, 2010).

In addition to supporting embodied processes in emotion concepts, the present results suggest that simulation also underlies the understanding of conceptual references to non-emotional mental states, such as experiences of thinking, remembering, hunger and thirst (Barsalou, Niedenthal, Barbey, & Ruppert, 2003). Although there may be differences between emotional and non-emotional terms (valence, arousal, etc.), our studies point out to important similarities. Most notably, our findings indicate that understanding conceptual references to internal components of both emotional *and* non-emotional states involves internal simulation. This is consistent with the recent suggestion that both emotional states (disgust, anger and other forms of emotional awareness) and cognitive operations (feeling of knowing, sudden insight, decision making) are associated with activity in the anterior insular cortex (AIC), a brain area associated with feeling states and interoception (Craig, 2002, 2009). Hence, an interesting and important avenue for further research is to test whether understanding sentences describing internal components of emotional and non-emotional mental states is accompanied by activity in the AIC. Such a finding would be an important addition to brain imaging studies that demonstrated activity in 'classic' modality-specific areas when people verify perceptual properties (Goldberg, Perfetti, & Schneider, 2006; Kan, Barsalou, Solomon, Minor, & Thompson-Schill, 2003).

In short, our findings highlight two important points. First, switching between sentences about mental states with internal and external focus has processing costs. This suggests that internal states are simulated in a separate "modality" (Barsalou, 1999; Craig, 2009). Second, although important aspects of diverse mental states, such as anger, exhaustion, and remembering, are processed

uniquely, their processing may rely on a shared simulation mechanism. This mechanism allows us to grasp mental states from inside out.