Investigating the association between valence and elevation with an implicit association task that requires upward and downward responding*

Investigando la asociación entre la valencia y la elevación con una tarea de asociación implícita que requiere respuestas ascendentes y descendentes

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ABSTRACT

In three experiments (total $N = 96$), we investigated the origins of effects of associations between affective valence and spatial elevation (or verticality). To that end, we used a congruence measure. We used spatial and affective stimuli, like the words "up" and "happy". Spatial stimuli had to be categorized as elevated or less elevated and affective stimuli as positive or negative. Critically, in congruent conditions, associated spatial and affective stimuli required the same response and less associated stimuli required different responses, whereas in incongruent conditions, associated spatial and affective stimuli required different responses, but less associated stimuli required the same response. The results supported the assumption that valence-elevation associations exist in semantic memory: faster responses in congruent than incongruent conditions were observed with (I) words (Experiments 1 and 2), (II) pictures and words (Experiment 3), and (III) increased as a function of the centrality of the spatial meaning for the spatial words (Experiments 1 vs. 2). We discuss the implications of our results for the Implicit Association Test (IAT).

Key words authors
Implicit Association Test, Valence and Spatial Elevation Conguence, Change Task, S-R Compatibility.
Key words plus
Cognitive Science, Perception, Quantitative Research.

RESUMEN

En tres experimentos ($N = 96$) se investigaron los orígenes de los efectos de las asociaciones entre la valencia afectiva y la elevación espacial (o verticalidad). Para tal fin, se utilizó una medida de congruencia. Se usaron estímulos espaciales y afectivos, como las palabras "arriba" y "feliz". Los estímulos espaciales tenían que ser categorizados como elevados o menos elevados y los estímulos afectivos como positivos o negativos. En las condiciones congruentes, los estímulos asociados espacial y afectivamente requerían la misma respuesta y los estímulos menos asociados diferentes respuestas, mientras que en las condiciones incongruentes, los estímulos asociados requerían respuestas diferentes y los estímulos menos asociados la misma respuesta. Los resultados apoyaron la hipótesis de que existen asociaciones de valencia-elevación en la memoria semántica. Se observaron respuestas más rápidas en las condiciones congruentes que en las incongruentes con (1) palabras (Experimentos 1 y 2), (II) imágenes y palabras (Experimento 3), y (III) incrementando en función de la centralidad del significado espacial de las palabras espaciales (Experimentos

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1 vs 2). Se discuten las implicaciones de nuestros resultados para el Test de Asociación Implícita (IAT).

Palabras clave autores
Test de Asociación Implícita; Congruencia Elevación-Valencia, Tarea de Cambio, Compatibilidad S-R.
Palabras clave descriptores
Cognitive Science, Perception, Quantitative Research.

Introduction

Language use points to the existence of associations between affective meaning and spatial connotation. Metaphors such as "to be deeply grieved", "to hit rock bottom", "to be in low spirits", "to look down on someone", and "to be in high spirits", "to be on top of the world", or "to be on cloud nine", suggest that verbal connotations of spatially low elevation go together with affectively negative valence, whereas connotations of spatially high elevation co-occur with affectively positive valence. At least in some instances of metaphor processing, it is possible that the corresponding association is created *ad hoc* to understand the meaning of a particular verbal metaphor (Camac & Glucksberg, 1984; Fauconnier & Turner, 1998). However, according to another view, verbal metaphors can also reflect memory representations used for multiple purposes besides metaphor comprehension (Lakoff & Johnson, 1980, 1999).

A valence-elevation association in semantic memory, for example, might be due to repeated couplings between subjective experiences of (a) being in a positive mood and (b) having an upright posture (Duclos, Laird, Schneider, Sexter, Stern & Van Lighten, 1989; Grady, 1997, cited after Lakoff & Johnson, 1999; Schnall & Laird, 2003). Such enduring associations can be used to comprehend thoughts and experiences in a variety of everyday situations besides verbal metaphors themselves (Barsalou, 1999, 2008; Lakoff & Johnson, 1980).

In line with this assumption, participants not only create valence-elevation associations to understand the meaning of an actually encountered verbal metaphor. Instead valence-elevation associations affect performance, even where no metaphor understanding is required (Horstmann, 2010; Horstmann & Ansorge, 2011; Meier & Robinson, 2004; Wapner, Werner, & Krus, 1957). For example, classification time for words as being positive or negative is better in a congruent condition, in which the vertical position of a word on a computer screen corresponds to the word's affective valence connotation, than in an incongruent condition, in which vertical position and affective valence connotation do not correspond to one another, despite the fact that the task does not require any verbal metaphor understanding at all (Meier & Robinson, 2004). It could be, for example, that spatial position information facilitates the recognition of an affective target by means of spreading activation between related (or similar) representations within semantic memory (Meyer & Schvanefeldt, 1971; Morton, 1969; Neely, 1991; but see Ratcliff & McKoon, 1988).

In the present series of studies, we tested three hypotheses concerning the valence-elevation association. First, we wanted to test whether a word's evaluative and spatial meaning are indeed responsible for the valence-elevation association effect. This is not entirely certain because many words with very heterogeneous meanings have been used in past studies of the effect. For example, Meier and Robinson (2004) used words, such as "dead" or "heaven" for their affective classification task. It is possible that some of the spatial connotations of these words had little to do with their valence, but may instead be inherent in their semantic meaning. To test the elevation-valence association in the present study, we used words with a spatial or an evaluative connotation in Experiment 1, but we used words with a spatial or an evaluative denotation in Experiment 2.

In both experiments, we tested whether word classification was facilitated in congruent conditions (with the same joint response for associated meanings of spatial and affective words, and with different responses for less associated words), as compared to incongruent conditions (with the same joint response for less associated words, and with different responses for more associated words). If a word's evaluative or spatial meaning accounts for what seems to be a valence-elevation association effect, the association effect or congruence effect should be stronger with evaluative and spatial word denotations (in Experiment 2), than with evaluative and spatial word connotations (in Experiment 1).

As a second goal of the present series of studies, we investigated whether the valence-elevation association can be corroborated with non-verbal stimuli (cf. Horstmann & Ansorge, 2011). If the valence-elevation effect has a semantic origin and not merely a lexical origin, we should be able to find a facilitating influence of semantically congruent or associated stimuli on categorization performance, even if categorizations concern spatial words, such as "up" and "down", on the one hand, and of affective (positive and negative) faces on the other hand.

Finally, we also tested whether the valence-elevation association contributed to a stimulus-response (S-R) compatibility effect. S-R compatibility effects concern faster responses to compatible stimuli, than to incompatible stimuli (Fitts & Seeger, 1953). For instance, participants respond faster to the word "right" with a right-hand key-press and to the word "left" with a left-hand key press (Proctor & Wang, 1997). An analogous compatibility effect should be created by spatial words denoting different elevations (e.g., "up" and "down") when an upward or a downward response is required, and a compatibility effect may even be found with valence words that have a particular spatial connotation. The latter theoretical possibility was raised in the study done by Meier and Robinson (2004). These authors speculated that the association between valence and elevation could partly be due to embodied cognition.

According to the concept of embodied cognition, the meaning of valence could be rooted in sensorimotor representations (cf. Barsalou, 1999, 2008; Casasanto, 2009; Giessner & Schubert, 2007; Stepper & Strack, 1993; Schubert, 2005). For example, positive feelings might be associated with being picked up by a caregiver during childhood, and negative feelings could go along with being put down by the caregiver. Also, positive feelings of pride might be associated with a more upright than slouched position (Stepper & Strack, 1993), and more appreciation of higher than lower (sic!) social ranks could result from basic experiences, such as having to look up to a physically superior and therefore socially dominating conspecific (cf. Schubert, 2005). As a consequence of such sensorimotor experiences, a positive word, such as the word "happy", might be able to facilitate an upward response, much as a spatial word (like "above") would be.

Experiment 1

Here, we wanted to confirm a congruence effect (CE) between affective valence and spatial elevation connotation. If associations between affective and spatial meaning are used in contexts besides metaphor understanding, we expected a corresponding CE in a non-metaphorical classification task (cf. Meier & Robinson, 2004). In a procedure similar to the implicit association test (IAT) (Greenwald, McGhee, & Schwartz, 1998), but using upward versus downward response movements instead of left-hand versus right-hand key presses, participants classified spatial targets. They discriminated words like "balloon" (up targets) and "train" (down targets) by their vertical meaning (whether they could be found in the sky or only on the ground). They also classified affective targets within the same blocks. They discriminated words like "friend" (negative targets) and "enemy" (positive targets) by their affective meaning.

In the congruent conditions, the long-term meaning of the stimuli supported the online retrieval of the short-term stimulus-response (S-R) mappings during a trial because semantically related targets required the same response and semantically unrelated targets required different responses (see Figure 1). For instance, up targets and positive targets required an upward key press, while down targets and negative targets required a downward key press. In the congruent condition, participants might even use the shared spatial meaning of affective and spatial targets to simplify the mapping rule offline in advance of all trials, and to respond to even the affective targets by their spatial meaning (cf. Klauer & Mierke, 2005).

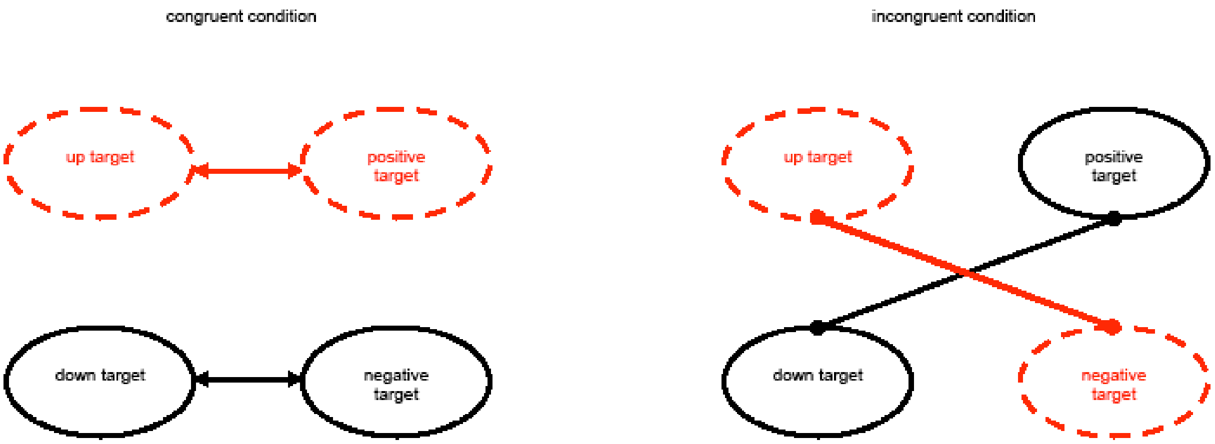

Figure 1: Model of the semantic associations underlying the congruence effect (CE).

On the left: Targets (ellipses), which are semantically associated are connected with a double arrow to symbolize mutual facilitation. On the right: Semantically less associated targets are connected with knob-end lines to symbolize mutual interference. Left and right: Which of two responses a particular target required is depicted by whether the target is a broken ellipse (required response 1) or a solid ellipse (required response 2). On the left: In the congruent condition, the semantic association helps in representation, maintenance, or retrieval of the required responses: Related targets require the same response, and less related targets require different responses. On the right: In the incongruent condition, semantic associations interfere with representation, maintenance, or retrieval of the required responses: Related targets require alternative responses and less related target require one and the same response.

Source: Own work.

In the incongruent conditions, facilitation of online retrieval of S-R mappings was prevented. We put the long-term meaning of the targets in opposition to the targets' short-term response meaning: related targets required different responses, whereas unrelated targets required the same responses (see Figure 1). For example, up targets and negative targets required an upward key press, whereas down targets and positive targets required a downward key press. This also prevented a conceivable offline simplification of the mapping rule: Participants had to discern the affective and the spatial targets by different rules (cf. Klauer & Mierke, 2005). If semantic associations affect performance, we expected a CE, with better performance in congruent than in incongruent conditions.

We also aimed to discern the offline and the online explanation: We compared task-switching costs (cf. Rogers & Monsell, 1995) between congruent and incongruent conditions. According to the offline explanation, only in incongruent blocks, a trial-by-trial change of the type of target (affective or spatial) increases RTs because it requires a change of the task set. In congruent conditions, no change of the task set is required and no corresponding reaction time (RT) cost is expected. Therefore, we tested whether switch costs were indeed restricted to the incongruent blocks or whether they were also found in the congruent blocks.

According to the sketched rationale, De Houwer (2003) was probably correct to call a CE such as the present one an "S-R correspondence effect": The expected CE reflects facilitation of S-R selection processes. Yet we prefer to call it a "congruence effect" (or "CE") to clearly discern it from a "spatial S-R compatibility (or SRC) effect" that we also assessed: Our use of spatial upward versus downward responses provided us with an independent measure of the processing of spatial meaning. The spatial responses allowed us to assess whether at least the spatial meaning of the spatial targets had been processed: With spatially compatible responses (e.g., pressing the upper key to an up target), performance was expected to be better than with spatially incompatible responses (e.g., pressing the upper key to a down target) (cf. Ansorge, Kiefer, Khalid, Grassl, & König, 2010; Lu & Proctor, 2001; Proctor, Marble, & Vu, 2000). SRC could be assessed regardless of whether or not the expected CE resulted (see also Figure 6). For the sake of clarity, however, we postpone the analysis and discussion of SRC until after the final experiment.

Method

Participants. Thirty-two different participants (16 female, 16 male) participated in each of the experiments. The mean age of the participants in Experiment 1 was 24 years. Here and in the following experiments, participants were mostly students, native German speakers, had normal or fully corrected vision, and were paid for their participation (6,- € per hour).

Apparatus. The experiment was run on a computer that also collected the data. Stimuli were presented on a 15-inch (38.1 cm) color monitor. All responses were key presses with the right index finger on the numeric keypad of a standard keyboard. To start each trial, participants pressed the central key (digit 5). Next, depending on the mapping (see below) and on the target identity, participants had to respond with one of two further target key presses. These were the digit keys #8 (above the central key for an upward response) or #2 (below the central key for a downward response). Response latencies of target key presses were measured from target onset to the nearest millisecond. The participants were seated in a dimly lit room, 65 cm in front of the screen, with their line of gaze straight ahead and their heads supported by a headrest.

Stimuli and procedure. All targets were white words presented centrally on a dark computer screen. In each trial, only one target was shown for 500 ms at the screen center, either an affective target or a spatial target (see Table 1). Feedback about wrong responses was provided: In case of an error, the message “Wrong response!” was presented for 750 ms on the display.

Participants were informed in advance that the experiment consisted of five blocks and that response-relevant targets and the kind of responses required for the targets varied between different parts (blocks) of the experiment. However, the differences between the blocks were not detailed in advance. Instead, participants were asked to pay attention to the written instructions, which were presented on the display prior to each of the blocks, and to ask the experimenter for advice if they failed to understand any of the instructions (which was never the case).

In the first block (40 trials), participants responded to affective targets. Each target was presented twice (in a random order). Half of the participants were asked to press key #8 in response to a positive target and to press key #2 in response to a negative target, whereas the other half of the participants received an inverse S-R mapping rule.

In the second block (40 trials), participants responded to the spatial targets. Each of the spatial targets was presented twice (in a random order). Participants had to discriminate between objects that could be found in the sky (up-targets) and objects that can only be found on the ground (down-targets). Half of the participants had to press key #8 in response to an up-target and to press key #2 in response to a down-target, whereas the other half of participants received an inverse S-R mapping rule.

The third block (120 trials) was the first of two dual-target blocks in which participants responded to both the affective and the spatial targets. Each target was presented three times (in a random order). S-R mapping rules for the different targets were the same as in the preceding blocks. Participants were told to respond to the targets as in the previous blocks, and the particular written S-R mapping instructions were repeated once, prior to the first trial. For instance, participants were asked to give a response with key #8 to words denoting objects that could only be found in the sky and to words with a positive meaning, whereas they were asked to press key #2 in the case of words denoting an object that could only be found on the ground and of words with a negative meaning.

The fourth block was identical to the second block, with the exception of a reversed S-R mapping rule for the spatial targets. For instance, participants who in the third block pressed key #2 in response to up-targets and key #8 in response to down-targets

Table 1
Targets in Experiments (Exp.) 1-3.

Exp. 1		**Exp. 2**		**Exp. 3**	
Positive targets	Freiheit/freedom	Positive targets	lustig/jolly	Positive targets	smiling cartoon faces
	Liebe/love		glücklich/lucky		
	Gesundheit/health		freudig/cheerful		
	Frieden/peace		vergnügt/happy		
	Freund/friend		spaßig/funny		
	ehrlich/honest		mutig/brave		
	glücklich/lucky		stolz/proud		
	sanft/gentle		verliebt/loving		
	fröhlich/merry		fröhlich/merry		
	schön/beautiful		froh/joyful		
Negative targets	Strafe/punishment	Negative targets	furchtsam/fearful	Negative targets	frowning cartoon faces
	Krankheit/illness		ängstlich/anxious		
	Hass/hate		bekümmert/worried		
	Krieg/war		traurig/sad		
	Feind/enemy		zornig/furious		
	verlogen/lying		hasserfüllt/full of hate		
	traurig/sad		wütend/enraged		
	grob/rude		frustriert/frustrated		
	enttäuscht/disappointed		beschämt/ashamed		
	hässlich/ugly		schuldig/guilty		
Up-targets	Stern/star	Up-targets	hoch/high	Up-targets	hoch/high
	Mond/moon		oben/top		oben/top
	Wolke/cloud		aufwärts/upward		aufwärts/upward
	Komet/comet		hinauf/up		hinauf/up
	Sonne/sun		empor/upward		empor/upward
	Flugzeug/airplane		darüber/above		darüber/above
	Ballon/balloon		gehoben/elevated		gehoben/elevated
	Helikopter/helicopter		erhöht/raised		erhöht/raised
	Zeppelin/zeppelin		aufsteigend/rising		aufsteigend//rising
	Gleitschirm/hang-glider		steigend/rising		steigend/rising
Down-targets	Feld/field	Down-targets	tief/deep	Down-targets	tief/deep
	Wald/forest		unten/down		unten/down
	Wiese/meadow		hinab/downward		hinab/downward
	Grube/cavity		abwärts/downhill		abwärts/downhill

now had to press key #8 in response to up-targets, and key #2 in response to down-targets. Prior to this block, participants were told by written instructions that they would "learn 'reversed responses' to the target words of the second block", and afterwards this mapping rule was detailed once in the written instructions on the display prior to the first trial.

The fifth block was the second dual-target block. It was identical to the third block, with the exception that the changed S-R mapping rule for the spatial targets (which had been practiced in the fourth block) still applied. Note that the S-R mapping rule for the affective targets never changed. Participants were told "to respond to the targets of the third block and to use the new S-R mapping rule that was practiced in the fourth block for the spatial words, but not for the affective targets"; the latter required the same responses as before (i.e., as in the first and third blocks), which was also explained to the participants. Afterwards, the S-R mapping rule was detailed in the written instructions on the display. No visible reminders of the S-R mapping rules were presented along with targets in all of the blocks, but an error feedback was provided after each incorrect trial, in order to ensure accurate performance overall.

As a consequence of the manipulations, for half of the participants conditions were congruent in the first dual-target block (block 3), and for half of the participants conditions were congruent in the second dual-target block (block 5). Note also that the procedure implies that influences of spatial S-R compatibility (between spatial targets and spatial responses) were balanced across blocks, and that the sequence in which different spatial compatibility conditions applied (spatially compatible S-R conditions before vs. after the spatially incompatible S-R conditions) was balanced across participants. In the dual-target blocks, no signal was presented to the participants to signify which classification (i.e., a classification of the spatial meaning, or a classification of the affective meaning of the current word) was required. Therefore, the target words themselves had to be used to recall the pertaining classification rules.

Participants had to give fast and accurate responses to the targets. The inter-trial-interval was 2,100 ms. This was also the maximal allowed latency of the responses. The whole experiment took about half an hour, including the instructions (presented at the beginning of each block), and a practice period of 20 trials prior to the first block.

Analyses. ANOVAs were conducted on mean RT (Reaction Time) and mean arcsine-transformed PE (Percentage of Errors) of the third and the fifth block. When necessary, degrees of freedom were adjusted by Greenhouse-Geisser coefficients ▯. Data from the first two trials of each of the dual-target blocks were excluded from the analyses. Differences between cell means of the blocks were tested by post-hoc *t*-tests. Congruence effects were expected to show up as significantly better performance in congruent blocks, in which associated words mapped on the same response, than in incongruent blocks, in which less associated words mapped on the same response. Additional *t*-tests were conducted to analyze unexpected differences.

Results

See Figure 2 for the results. Out of all trials, 1.9% were excluded from the analyses because responses were faster than 100 ms or slower than 2,100 ms. Individual mean latencies of correct responses and PEs were subjected to separate repeated-measures ANOVAs, both with *congruence* (congruent dual-target block; incongruent dual-target block), *target* (positive target, negative target, up-target, down-target), and trial-by-trial *target type relation* (target type switch vs. target type repetition), as within-participant variables.

RTs. In RTs, there were significant main effects of congruence, $F(1,31) = 5.76$, $p < 0.05$, with faster responses under congruent (876 ms) than incongruent conditions (937 ms), of target, $F(3,93) = 2.97$, $p < 0.05$, reflecting faster responses to up targets (887 ms) than to down targets (916 ms), positive targets (905 ms) and negative targets (918 ms), all significant ps < 0.01, and of trial type relation, $F(1,31) = 87.19$, $p < 0.01$, with faster responses in repetition (874 ms) than switch conditions (939 ms). In addition, we found significant interactions of Congruence x Trial Type Relation, $F(1,91) = 6.11$, $p < 0.05$, and of Trial Type Relation x Target, $F(3,93) = 5.25$, $p < 0.01$. CEs (incongruent RT – congruent RT) were lower in repetition trials (40 ms), $t(31) = 1.87$,

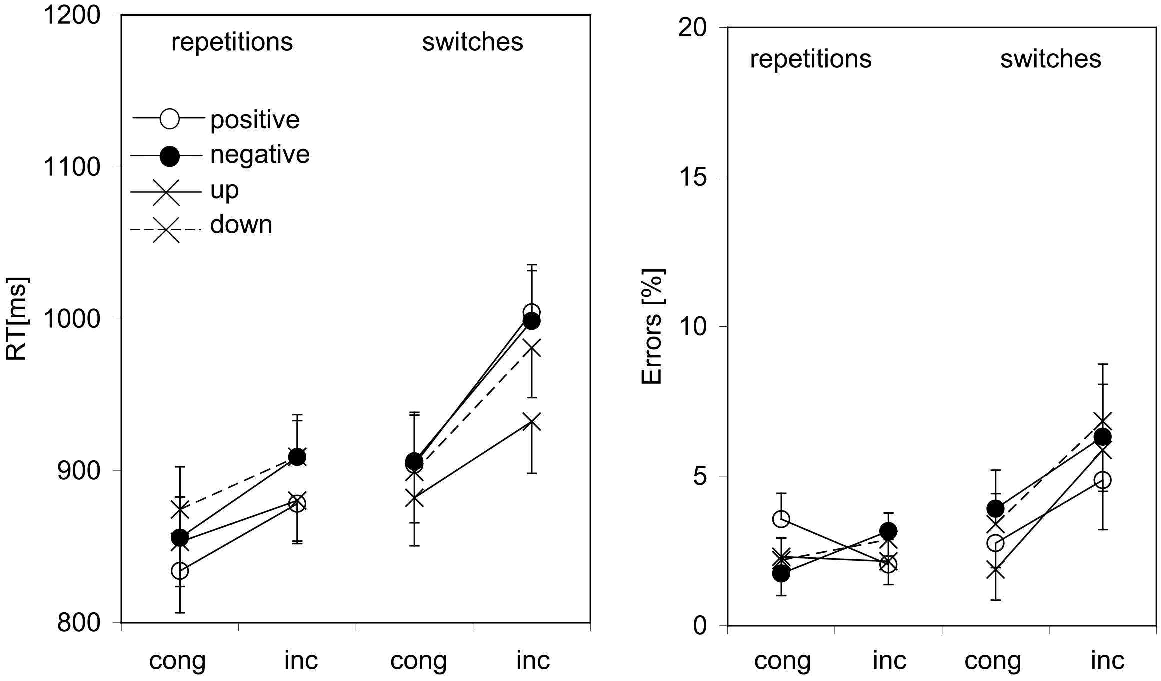

Figure 2: Means of Reaction Times (RT) (in ms), on the left, and of percentages of errors (PE), on the right, and corresponding standard errors, as a function of target type (positive, negative, up, down), congruence (congruent, incongruent), and trial-by-trial target type relation (repetition, switch) in Experiment 1.
Source: Own work.

$p < 0.05$ (one-tailed), than in switch trials (81 ms), $t(31) = 2.63$, $p < 0.05$.

Correspondingly, switch costs (switch RT – repetition RT) were lower in congruent (44 ms), $t(31) = 5.54$, $p < 0.01$, than in incongruent conditions (85 ms), $t(31) = 6.46$, $p < 0.01$. Switch costs were also stronger with positive targets (positive: 98 ms), $t(31) = 9.15$, $p < 0.01$, than with all other targets (negative: 70 ms; up: 41 ms, down: 48 ms), all three *t*s: $4.0 < t < 5.0$, all three *p*s < 0.01.

PEs. No effects were found in the ANOVA of the arc-sine transformed PEs.

Discussion

In Experiment 1, we found the expected CE: RTs and PEs indicated more efficient performance under congruent than incongruent conditions. The CE was found with affective and (weaker) with spatial targets. Thus, the CE between target types reflected mutual, but not symmetrical, influences between spatial and affective meaning. The fact that the CE was low for spatial targets probably reflected that all targets carried their spatial meaning only as connotations.

Part of the CE was brought about by offline recoding of the S-R mappings in the congruent blocks. This was suggested by the lower CEs on repetition than on switch trials (or higher switch costs in incongruent than congruent blocks). Note, however, that a significant CE was also found when we selectively looked at the repetition conditions. (Correspondingly, switch costs were also found in the congruent blocks.) Thus, at least some of the targets required maintenance of separate S-R mappings, even in congruent blocks. For instance, positive targets created somewhat increased switch costs (reflected in a significant interaction between congruence and target type), suggesting that they more frequently required a separate S-R mapping from the spatial targets in congruent blocks, too.

Experiment 2

If the CE reflected an association between the spatial connotation of the affective target words and the spatial meaning of the spatial target words, we expected that when using spatial target words with a spatial denotation rather than connotation, the CE would become stronger. This prediction was tested in Experiment 2 in which we used spatial prepositions as spatial targets.[1]

Method

Participants. Mean age of the participants in Experiment 2 was 25 years. Sixteen participants were female and sixteen were male, and all were native German speakers.

Apparatus, stimuli, and procedure. These were exactly the same as in Experiment 1, with the exceptions of a changed set of target words and an altered task. Affective target words were now emotional adjectives. This was done to secure that indeed affective meaning of the targets accounted for the CE. Spatial targets were spatial prepositions. For details, refer to Table 1. Concerning the task, like in Experiment 1, participants had to discriminate between the affective targets as either having a negative or a positive meaning. However, for the spatial targets the task was slightly altered: participants now had to indicate whether a spatial target denoted a position above or a direction toward such a position (e.g., the words “on” or “upward”), or a position below or a direction toward such a position (e.g., the words “under” or “downward”).

Results

See Figure 3 for the results. Out of all trials, 3.5% were excluded from the analyses because responses were faster than 100 ms or slower than 2,100 ms.

RTs. In RTs, we observed a significant main effects of congruence, $F(1,31) = 25.5$, $p < 0.01$, with faster responses under congruent (897 ms) than incongruent conditions (1,051 ms), of target, $F(3, 93) = 29.13$, $p < 0.01$, with faster responses to positive targets (895 ms) than to negative targets (998 ms), up-targets (997 ms), and down-targets (1,007 ms), all *p*s < 0.01 (Bonferroni-corrected), and of target type relation, $F(1,31) = 68.46$, $p < 0.01$, with faster RTs for repetitions (938 ms) than switches (1,011 ms). In addition, we observed significant interactions of Congruence x Target Type Relation, $F(1,31) = 18.32$, $p < 0.01$, and of Target Type Relation x Congruence, $F(3,93) = 2.99$, $p < 0.05$. CEs (incongruent RT – congruent RT) were larger in repetition trials (119 ms), $t(31) = 4.36$, $p < 0.01$, than in switch trials (187 ms), $t(31) = 5.36$, $p < 0.01$. Accordingly, switch costs (switch RT – repetition RT) were again stronger in incongruent (107 ms), $t(31) = 7.31$, $p < 0.01$, than in congruent conditions (39 ms), $t(31) = 4.75$, $p < 0.01$, and they were largest with the negative targets (104), $t(31) = 6.3$, $p < 0.01$, followed by positive (79 ms), down (57 ms), and up targets (52 ms), all three *t*s: $4.1 < t < 5.30$, all *p*s < 0.01.

PEs. There was a main effect of congruence $F(1,31) = 8.11$, $p < 0.01$, in PEs, with lower PEs under congruent (4.5%) than incongruent conditions (7.3%).

Comparison of RTs between Experiments 1 and 2 by an ANOVA, with the additional between-participants factor Experiments (1 vs. 2), and with data collapsed across levels of the variable target type relation, revealed a highly significant main effect of congruence, $F(1,62) = 28.17$, $p < 0.01$, and significant interactions of Congruence x Experiments, $F(1,62) = 5.39$, $p < 0.05$ – confirming that the numerically stronger congruence effect in Experiment 2 than 1 was statistically significant –, and of Target x Experiments, reflecting the selective presence of a main effect of target in Experiment 2 and its absence in

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[1] This was confirmed by asking sixteen fresh participants to rate centrality of spatial meaning and of affective meaning for the spatial target words and the affective target words used in Experiments 1 and 2 on a five-point scale, with a value of 1 indicating low centrality of spatial meaning and a value of 5 for high centrality. The results reflected that average centrality of spatial meaning for spatial targets of Experiment 1 (3.1) was significantly below that in Experiment 2 (4.0), $t(15) = 3.15$, $p < 0.01$, whereas there were no significant differences between centrality of spatial meaning for affective targets as well as for affective meaning of spatial and affective targets between Experiments 1 and 2, all *t*s $(15) < 2.0$, all *p*s > 0.06.

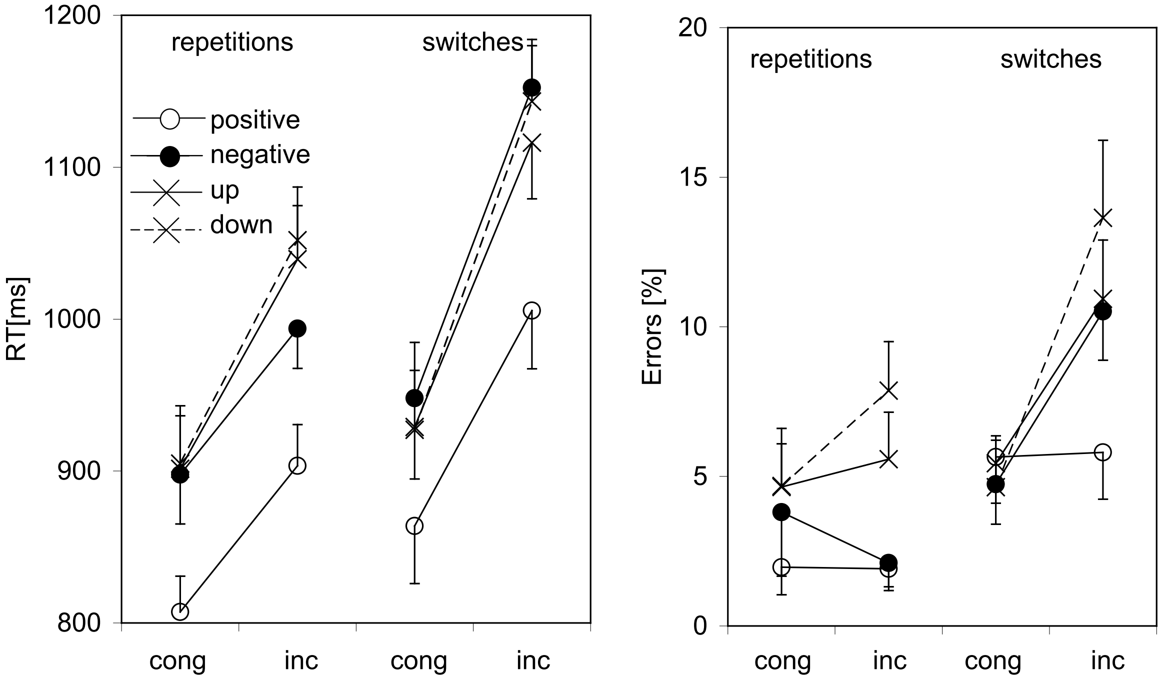

Figure 3: Means of Reaction Times (RT)(in ms), on the left, and percentages of errors, on the right, and corresponding standard errors, as a function of target type (positive, negative, up, down), congruence (congruent vs. incongruent), and trial-by-trial target type relation (repetition, switch) in Experiment 2.
Source: Own work.

Experiment 1. There was also a tendency towards a main effect of Experiments, $F(1,62) = 3.72$, $p = 0.06$, reflecting overall longer RTs in Experiment 2 than 1. All other interactions were non-significant, all Fs < 1.9, all ps > 0.18.

Discussion

Results of Experiment 2 were in line with the hypothesis that the CE reflected the association between spatial meaning of affective words and of spatial words (or between the affective connotation of spatial words and affective words). Increasing the centrality of the spatial meaning for the spatial target words (by using spatial prepositions) from Experiment 1 to 2 also increased the CE attributed to the association between the spatial meaning of the spatial words and the spatial connotation of the affective words. This was especially true of the spatial targets. (As different observers and words were used in Experiments 2 than 1, however, we admit that other interpretations are also conceivable.) Also, CEs were of about equal size for all targets used. This observation fits nicely with a mutual (and even symmetrical) semantic facilitation between the semantically related words.

Again, we also found some support for the offline explanation because congruence effects were stronger in switch conditions than in repetition conditions. (Likewise, switch costs were larger in incongruent than congruent conditions.) Like in Experiment 1, however, a residual switch cost was also found in the congruent block. Thus, at least, some of the targets required maintenance of different S-R mapping rules in the congruent blocks, too. Again, the necessity to use separate S-R mappings seemed to differ for different targets, reflected in a significant interaction between trial relation type and target type.

We also observed faster responses to positive than to all other targets. Word frequencies were not responsible: Linear regression of mean RTs on the frequency of the different target words (*Wortschatz Lexikon online.* Retrieved from http://www.wortschatz.uni-leipzig.de/) yielded variable slopes and low coefficients, average *B* = 0.003, $t < 1.0$. Maybe facilitated sensory processing of positive targets contributed to the effect (cf. Palazova, Mantwill, Sommer, & Schacht, 2011; Schupp, Junghöfer, Weike, & Hamm, 2003).

Experiment 3

If the CE reflected semantic associations, we should find a CE by using words as well as pictures as targets (cf. De Houwer & Hermans, 1994; Glaser & Glaser, 1989; Tannenhaus, Spivy-Knowlton, Eberhard, & Sedivy, 1995). Along these lines, the space-valence association can even cross modalities (i.e., from visual affective stimuli to "high" vs. "low" tones) (cf. Horstmann, 2010; Weger, Meier, Robinson, & Inhoff, 2007). In contrast, a lexical CE should be restricted to words. Meier and Robinson's (2004) results suggested a semantic origin: They found an impact of spatial positions on processing of affective word meaning. Could we find a CE with the roles of the verbal and pictorial stimuli being reversed? We tested this in Experiment 3 with pictorial affective face expressions and spatial target words as stimuli.

Method

Participants. Sixteen male and sixteen female participants took part in Experiment 3. Mean age of the participants was 26 years. The mother tongue of all participants was German.

Apparatus, stimuli, and procedure. These were the same as in Experiment 2, with the exception of a changed set of affective targets. Smiling or frowning cartoon faces were used as positive and negative affective targets, respectively (see Figure 4). The faces had a diameter of 1° and were presented centered on the same screen positions as the target words.

Results

See Figure 5 for the results. Out of all trials, 2.3% were excluded from the analyses because responses were faster than 100 ms or slower than 2,100 ms.

RTs. In RTs, we found significant main effects of target type relation (1,31) = 123.58, $p < 0.01$, and of target, $F(3,93) = 61.06$, $p < 0.01$. The effect of congruence was only marginally significant, $F(1,31) = 3.3$, $p = 0.08$. Responses were faster in congruent (842 ms) than incongruent conditions (950 ms), for both affective targets (positive: 810 ms; negative: 802 ms), both *p*s < 0.01, than for both spatial targets (up: 979 ms; down: 994 ms), and they were numerically faster

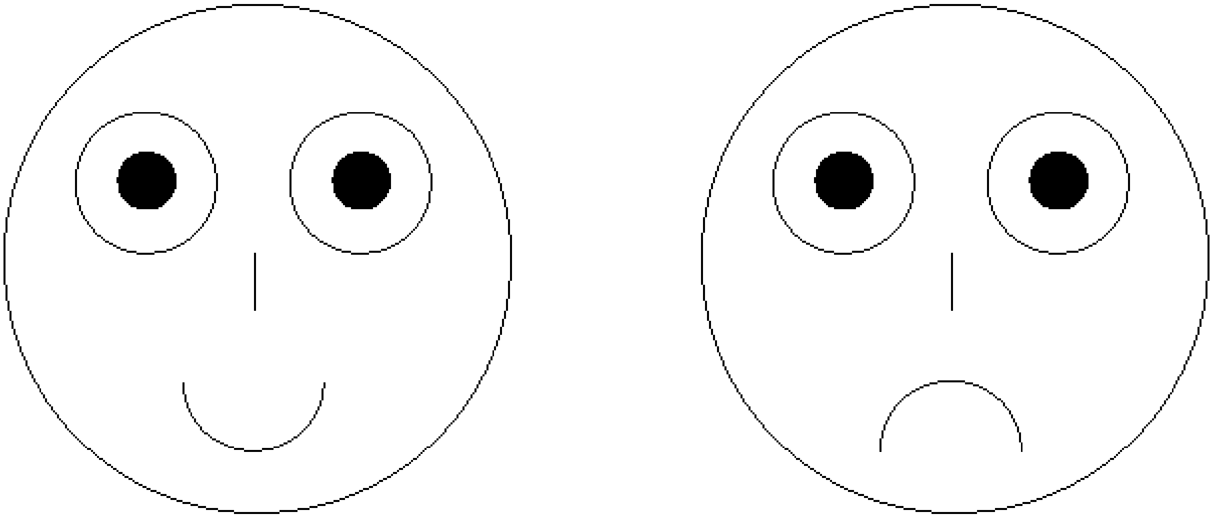

Figure 4: Affective targets used in Experiment 3; positive target on the left; negative target on the right.
Source: Own work.

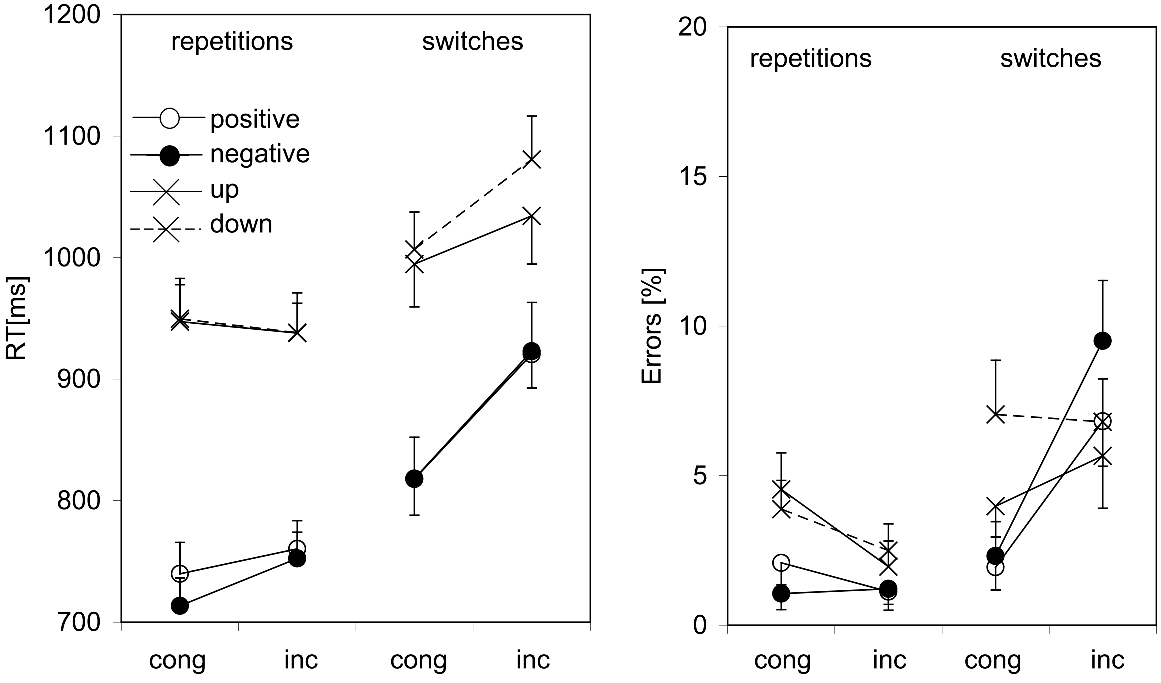

Figure 5: Means of Reaction Times (RT) (in ms), on the left, and of percentages of errors, on the right, and the corresponding standard errors, as a function of target type (positive, negative, up, down), congruence (congruent, incongruent), and trial-by-trial target type relation (repetition, switch) in Experiment 3.
Source: Own work.

for repetitions (873 ms) than switches (918 ms). We also found significant interactions of Congruence x Trial Type Relation, $F(1,31) = 18.16$, $p < 0.01$, and of Trial Type Relation x Target, $F(3,93) = 3.71$, $p < 0.05$. CEs (incongruent RT – congruent RT) were selectively present in switch trials (80 ms), $t(31) = 2.68$, $p < 0.05$, whereas no significant CE was found in repetition trials (10 ms), $t < 1.0$. Correspondingly, switch costs (switch RT – repetition RT) were once more larger in incongruent (142 ms), $t(31) = 10.43$, $p < 0.01$, than in congruent conditions (72 ms), $t(31) = 6.15$, $p < 0.01$. Again, switch costs were highest for the negative targets (138 ms), $t(31) = 8.48$, $p < 0.01$, followed by positive (119 ms), down (100 ms), and up targets (72 ms), all three *t*s: $6.1 < t < 6.9$, all three *p*s < 0.01.

PEs. In PEs, we found a significant main effect of targets, $F(3,93) = 3.71$, $p < 0.05$, with lower PEs for positive (3.0%) than for down targets (5.1%), $p < 0.05$, and PEs for negative (3.5%) and up targets (4.0%) lying in-between.

Discussion

In accordance with the hypothesis that the space-valence congruence effect reflected semantic associations, we observed a CE based on affective pictures and spatial words at least in the switch conditions. Together, our results and those of others (e.g., Meier and Robinson, 2004) therefore, suggest that the cross-format semantic influences of affective and spatial meaning were mutual (but see Horstmann, Becker, Bergmann, & Burghaus, 2010, for an alternative interpretation). The diminution of the present CE in comparison to Experiment 2 was due to a stronger influence of offline recoding in the present than in the preceding experiments. The CE was absent in the repetition conditions. This indicated that participants used only one S-R mapping rule to respond to affective, as well as spatial targets in the congruent blocks (cf. Klauer & Mierke, 2005).

Maybe upward and downward bent mouths of affective targets allowed efficient recoding as spatial features and of the S-R mapping rule for the affective targets. In contrast, the spatial connotation of the affective words in the preceding experiments was less suited for that purpose. Alternatively, it could be that lexical CEs in the preceding experiments contributed to online use of spatial semantics. Because with the present experiment's faces the lexical CE was ruled out, the online-mediated CE would have likewise been blocked.

Besides, faster RTs for both faces (with their higher frequency of presentation, in comparison to the less frequent twenty spatial target words) could have reflected that participants inferred (emotional) meaning faster from a more naturalistic stimulus (i.e., a face) than from arbitrary symbols (i.e., words).

The faster responses for the affective targets are interesting for the following reason, too. Some authors believe that CEs are better explained by salience than by semantics. Two salient stimuli mapping on one response are then considered congruent. They should facilitate responses relative to incongruent conditions, with "mixed mappings" of salient and less salient stimuli to one response (cf. Rothermund & Wentura, 2004). In this experiment, the most salient stimuli (the two faces), never mapped on the same response. The salience manipulation therefore referred to a category (affective vs. spatial targets) that was orthogonal to that used for the CE. In agreement with the salience account,

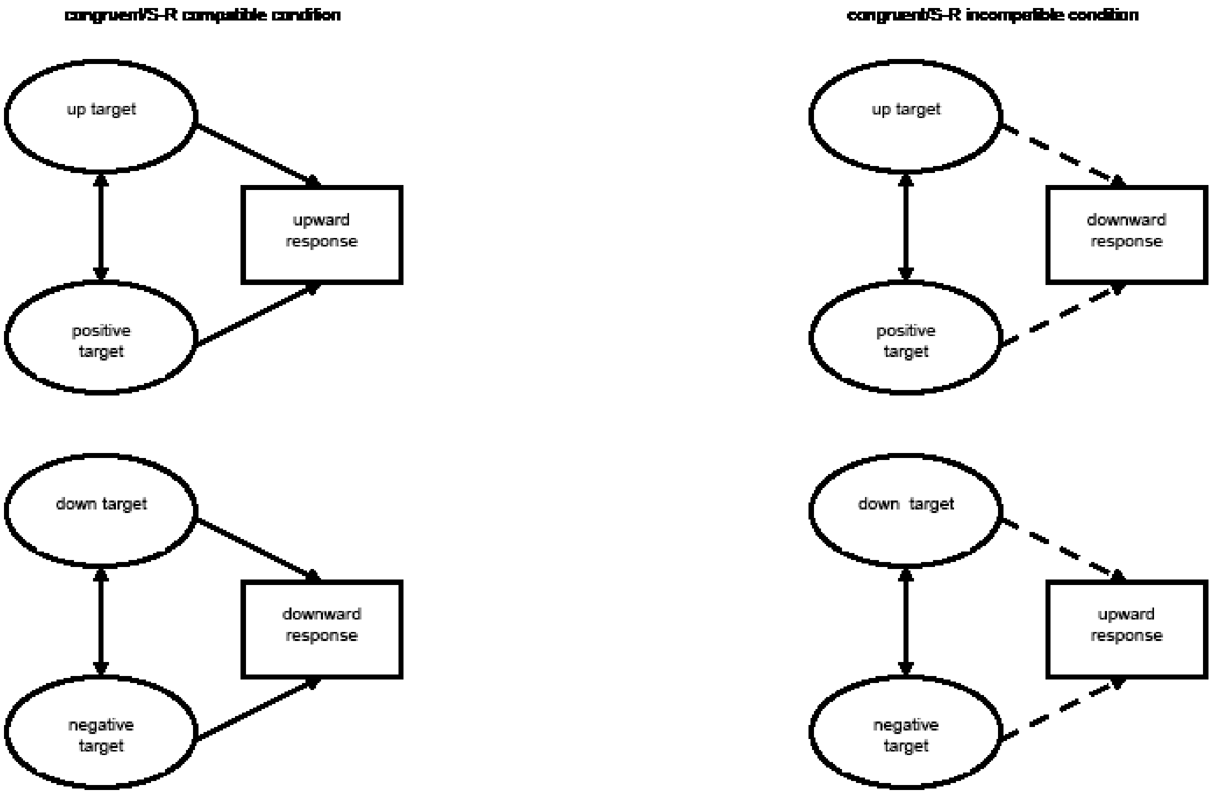

Figure 6. *Illustration of the spatial S-R compatibility (SRC) levels that we realized under semantically congruent conditions. On the left: In S-R compatible conditions, targets (ellipses) shared their spatial meaning with the required responses (rectangles). Therefore, S-R compatible targets could have facilitated the required responses (e.g., by response activation). Solid arrows pointing to the responses indicate this. On the right: In S-R incompatible conditions, targets shared spatial meaning with the alternative responses. Therefore, S-R incompatible targets had the potential to interfere with the required responses. The broken arrows pointing to the responses symbolize this.*

Source: Own work.

the CE dropped in comparison to the preceding experiments. However, if the CE were solely due to salience, we would have had little reason to expect any CE in the current experiment at all. Because the CE was found basically intact in the present experiment, we conclude that a significant part of the CE reflected semantic associations.

SRC effects in Experiments 1-3

A final point of concern is the influence of spatial SRC (see Figure 6). From the outset, we argued that spatial targets should lead to an SRC effect. For instance, responding with an upward key to an up target (S-R compatible condition) is probably faster than responding with a downward key to an up target (S-R incompatible condition).

Importantly, the SRC effects could have compromised CEs in the preceding experiments. For participants responding S-R compatibly in the incongruent condition but S-R incompatibly in the congruent condition, SRC effects would have counteracted CEs. For example, facilitation in S-R compatible compared to S-R incompatible conditions would have counteracted facilitation by congruent relative to incongruent conditions. Thus, the SRC effect would have subtracted from the CE. In principle, the same logic might apply for the affective targets: Spatially compatible responses (e.g., pressing of an upward key in response to a positive target) could be faster than incompatible responses (e.g., pressing of a downward key for a positive target). (This is particularly true of Experiment 3, with its upward and downward bent mouth lines in the affective targets.) To test this contention, we analyzed RTs with the additional variable SRC during the congruent conditions (compatible/congruent condition vs. incompatible/congruent condition).

Method

ANOVAs of correct mean RTs, one for spatial targets, and a second one for affective targets, included the additional between-participants factor Experiments (1 to 3) and SRC level during the congruent block (S-R compatible/congruent; S-R incompatible/congruent), abbreviated as SRC below. For these analyses, data were collapsed across levels of the variable target type relation.

Results

Affective targets. The ANOVA of the affective targets revealed significant main effects of congruence, $F(1,90) = 79.74$, $p < 0.01$, target, $F(1,90) = 26.66$, $p < 0.01$, and Experiments, $F(2,90) = 8.52$, $p < 0.01$. Responses were faster under congruent (RT = 848 ms) than incongruent conditions (RT = 938 ms), with positive (RT = 878 ms) than negative targets (RT = 909 ms), and in Experiment 3 (RT = 808 ms) than Experiments 1 (RT = 917 ms) and 2 (RT = 953 ms), with *p*s < 0.05 for the latter two. We also observed significant interactions of Congruence x SRC, $F(1,90) = 21.29$, $p < 0.01$, Congruence x Experiments, $F(2,90) = 5.64$, $p < 0.01$, and Target x Experiments, $F(2,90) = 25.54$, $p < 0.01$. The CE (incongruent RT – congruent RT) was stronger when congruent conditions were S-R compatible (97 ms), $t(47) = 9.03$, $p < 0.01$, than when congruent conditions were S-R incompatible (43 ms), $t(47) = 2.93$, $p < 0.01$.

The CE was also stronger in Experiment 2 (138 ms), $t(31) = 6.44$, $p < 0.01$, than in Experiments 1 (93 ms), $t(31) = 3.69$, $p < 0.01$, and 3 (60 ms), $t(31) = 3.62$, $p < 0.01$. Concerning the interaction of Target x Experiments, a significant advantage for positive (RT = 908 ms) relative to negative targets (RT = 998 ms) was found in Experiment 2, $t(31) = 9.58$, $p < 0.01$, but not in Experiments 1 and 3.

In addition, we tested whether upward and downward bent mouths in Experiment 3's affective targets created a spatial SRC effect (expressed as S-R incompatible RT – S-R compatible RT). Responses (collapsed across congruent and incongruent affective targets) were non-significantly lower in S-R compatible (RT = 784 ms) than in S-R incompatible conditions (RT = 834 ms), $F < 1.0$. This SRC effect of 60 ms lay in-between that of the affective targets in Experiments 1 (-19 ms), $F < 1.0$, and 2 (68 ms), $F(1,30) = 2.06$, $p = 0.16$.

Spatial targets. An ANOVA of RTs for the spatial targets led to significant main effects of congruence, $F(1,90) = 30.27$, $p < 0.01$, target, $F(1,90) = 8.65$, $p < 0.01$, and Experiments, $F(2,90) = 4.71$, $p < 0.05$. Responses were faster for congruent (RT = 929 ms) than incongruent conditions (RT = 1,006 ms), up targets (RT = 960 ms) than down targets (RT = 975 ms), and Experiment 1 (RT = 905 ms) than 2 (RT = 1,006 ms), $p < 0.05$, for the latter. (No significant differences existed between Experiment 3 [RT = 991 ms] and the other two experiments.) We also found significant interactions of Congruence x SRC, $F(1,90) = 136.19$, $p < 0.01$, Congruence x Experiments, $F(2,90) = 9.63$, $p < 0.01$, Target x SRC, $F(1,90) = 7.38$, $p < 0.01$, Congruence x Target x SRC, $F(1,90) = 5.2$, $p < 0.05$, and between all four variables, $F(2,90) = 3.79$, $p < 0.05$. To understand the interactions, we assessed CEs separately for each level of all the three remaining variables.

We found that an SRC effect sometimes counteracted the CE. For down targets, advantages ranged from 171 ms (in Experiments 1 and 3) to 373 ms (in Experiment 2) in S-R compatible/congruent relative to S-R incompatible/incongruent conditions. For up targets, these advantages were slightly larger in Experiments 1 (179 ms) and 3 (207 ms) but slightly lower in Experiment 2 (339 ms). Comparing S-R incompatible/congruent conditions with S-R compatible/incongruent conditions, the sign of the CE reversed. This was least so, only numerically the case in Experiment 2 (down targets: -25 ms; up targets: -37 ms), but significantly for the remaining up targets (in Experiment 1: -102 ms; in Experiment 3: -177 ms), and for the down targets in Experiment 3 (-113 ms), all significant *p*s < 0.05. In Experiment 1, we additionally found a non-significant reversal of -64 ms for the down targets if CEs were calculated with SRC effect opposing the CE.

Discussion

With the affective targets, CEs were straightforwardly identified under S-R compatible as well as S-R incompatible conditions. The CE was a little smaller in the latter conditions. This demonstrated that with the affective targets, a weak SRC effect might have counteracted but never overcame the CE. Additional analyses confirmed that in none of the three experiments, affective targets created a significant SRC effect.

For the spatial targets, CEs – that is, advantages in congruent relative to incongruent conditions – were found only if congruent conditions were also S-R compatible and incongruent conditions were also S-R incompatible. By contrast, when congruent conditions were S-R incompatible and incongruent conditions were S-R compatible, the performance difference reversed. Thus, as was to be expected and securing our interpretations, spatial SRC had a strong influence on performance with the spatial targets. On average, however, with the spatial targets a net CE in the preceding experiments was observed with performance averaged across (1) conditions with an SRC effect counteracting the CE (CE – SRC) plus (2) conditions with an SRC effect adding to the CE (CE + SRC).

General Discussion

On the basis of prior findings (Meier & Robinson, 2004; Weger et al., 2007), we expected a CE based on semantic space-valence associations. (a) Affectively positive was expected to be associated with spatially high and (b) affectively negative with spatially low. This contention was tested in a modified version of the IAT (Greenwald et al., 1998): In congruent conditions, semantically associated targets mapped on the same response (and less associated targets mapped on different responses). This is depicted in Figure 1. For example, participants used the same key for their judgment of the target word "happy" (as being positive) and the spatial target word "up" (as an elevated position). By contrast, in incongruent conditions, semantically less associated targets mapped on the same response. Likewise, in incongruent conditions, associated targets mapped on different responses. For example, participants pressed the same key for their judgment of "happy" (as positive) and of "down" (as a low position).

Under congruent conditions, participants could use the shared spatial meaning of the targets either online or offline. They could use reciprocal facilitation between semantically related concepts online (during the experiment) for successful retrieval of the currently pertaining S-R mapping rule. They could also use shared spatial meaning offline (prior to the trials) to simplify the S-R rule in congruent conditions (Klauer & Mierke, 2005): For example, for their judgments, the participants could discriminate the spatial instead of the affective meaning of the affective targets. This is a refinement of the semantic explanation and not an alternative to it because if no particular spatial meaning would be associated with positive versus negative targets in the first place, the simplification could not be made. In the incongruent condition, both online facilitation and offline simplification were not possible. Therefore, a CE was expected, with better performance in congruent than incongruent conditions.

The CE was found, less so with spatial connotations of affective target words (Experiment 1). This CE increased, once we used spatial prepositions with a spatial denotation (Experiment 2). In addition, we found the CE in a cross-format experiment, with affective pictures and spatial words (Experiment 3). This latter finding indicated that the CE was truly semantic and not restricted to the lexical level of word processing (cf. De Houwer & Hermans, 1994; Weger et al., 2007). Finally, a subsequent overall ANOVA confirmed that the CE was largely independent of a spatial SRC effect.

Implications for the IAT

Because we used an adapted version of the IAT, we want to detail a few implications for IAT research. First, our results showed that using affective stimuli does not secure that affective valence is responsible for the CE. Affective stimuli can bring about a CE on the basis of their spatial connotations. Therefore, our results add to the evidence that factors in addition to "prejudices" (i.e., in addition to valences) can contribute to IAT measures (cf. Brendl, Markman, & Messner, 2001).

Second, we ruled out salience as the sole explanation of the CE. According to Rothermund and Wentura (2004) congruence is based on the shared salience rather than the shared meaning of stimuli. Salience is not a long-term memory component. Salience can be manipulated in the experiment, for instance, by stimulus frequency. Salience is reflected in quicker (accurate) responses. In contrast to the salience explanation, in our Experiment 3, the two most salient stimuli – the faces – required alternative responses in congruent and incongruent conditions. Thus, the CE of Experiment 3 cannot be attributed to salience.

We admit, however, that salience could have contributed to CEs in the present Experiments 1 and 2. The diminution of the CE from Experiments 1 and 2 to 3 demonstrated that salience could indeed have boosted the CE, but the significance of the CE in the final experiment testified that semantically mediated CEs also contribute to IAT-like measures.

Third, our results supported Mierke and Klauer's (2003) offline explanation of the CE. According to the offline explanation, observers simplify the S-R rule in the congruent conditions. As a result, occasional task switching is restricted to the incongruent conditions. Task switching will increase RTs in incongruent compared to congruent conditions (Mierke & Klauer, 2003). This is exactly the pattern that was expressed in Experiment 3 in which the CE was found in the switch trials only. In Experiments 1 and 2, we also found that offline recoding contributed to the CE because CEs were larger in switch than in repetition conditions. However, because we also found (a) residual CEs in the repetition trials and (b) residual switch costs in the congruent blocks online influences of semantic relations at least partly accounted for the CE.

Admittedly, however, we did not use any additional signals to inform the participants about the actually pertaining classification rules (i.e., about whether the current target required a spatial or an affective classification). Instead, participants had to use the target words themselves to recall the currently pertaining classification rules. In this situation, potential differences between task-switching and task-repetition trials were mitigated to the extent that task cueing fostered these differences (for a review, see Kiesel et al., 2010). This might explain the difference between our findings and past studies that showed a selective IAT effect in task-switching trials.

Fourth, our results suggested that a close fit between the task (i.e., the required semantic discrimination) and the central semantic meaning of the targets under scrutiny fosters the CE. We observed this in comparison of CEs in Experiments 1 (with targets' spatial connotation resulting in a weaker fit) and 2 (with targets' spatial denotation resulting in a better fit).

Fifth, our results showed that the CE is not the same as a (spatial) SRC effect. With spatial targets, a spatial SRC effect was found (cf. Figure 6). Responses were faster in compatible conditions (e.g., if up targets required upward responses) than in incompatible conditions (e.g., if down targets required upward responses). Yet, comparison of net performance differences between (1) congruent/compatible minus incongruent/incompatible conditions and (2) congruent/incompatible minus incongruent/compatible conditions suggested that the SRC added to the CE if both effects drew performance differences in the same direction, and that the SRC subtracted from the CE effect if the effects were opposite to one another. With affective targets, a corresponding comparison suggested a slight interaction, with a lower congruence effect under S-R incompatible than S-R compatible conditions. Yet, with the affective targets, the CE was significant in the S-R incompatible conditions, too. Thus, the CE is not the same as an SRC. Backing up this conclusion, no main SRC effect was found for the affective targets.

This result seems to be at odds with De Houwer's (2003) taxonomy. According to De Houwer (2003), the CE of the IAT reflects an "irrelevant S-R correspondence" effect. De Houwer's position, however, can be maintained under the assumption that spatial S-R correspondence brings about its effects at different points in time. Independence between spatial SRC effects and (spatial) CEs could, thus, be reconciled with De Houwer's (2003) taxonomy if we consider the CE an "offline-mediated SRC effect", and the S-R compatibility effect proper as an online-mediated SRC impact. As explained above, there is good reason to assume that, at least the former assumption, holds true.

Having said this, two cautionary remarks are in order. First, in the present study, we devised a task, not a test. We did not test personality traits. Instead we used a modified IAT as one task for probing long-term memory. Second, as with the IAT, we did not ask our participants explicitly to use the long-term memory associations under scrutiny. In that respect, one might consider our task as an "implicit" measure. Yet this is not a crucial assumption in the present context. Our findings would not be invalidated if it turned out that our participants intentionally or "explicitly" simplified the congruent mappings, for instance.

To us, however, these differences between the current task and the IAT appear secondary. Therefore, much could be learned about the IAT itself from memory tasks as ours.

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