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That's Me in the Spotlight:

Self-Relevance Modulates Attentional Breadth

Marius Golubickis[1] and C. Neil Macrae[2]

[1]School of Psychology, University of Plymouth, Plymouth, England, UK
[2]School of Psychology, University of Aberdeen, Aberdeen, Scotland, UK

Address Correspondence to:

Marius Golubickis
School of Psychology
University of Plymouth
Drake Circus
Plymouth PL4 8AA
England, UK

Email: marius.golubickis@plymouth.ac.uk

Abstract

A core prediction of models of social-cognitive functioning is that attention is preferentially tuned to self-relevant material. Surprisingly, however, evidence in support of this viewpoint is scant. Remedying this situation, here we demonstrated that self-relevance influences the distribution of attentional resources during decisional processing. In a flanker task (*N* = 60), participants reported if to-be-judged stimuli either denoted, or were owned by, the self or a friend. A consistent pattern of results emerged across both judgment tasks. Whereas the identification of friend-related targets was speeded when the items were flanked by compatible compared to incompatible flankers, responses to self-related targets were resistant to flanker interference. Probing the origin of these effects, a further computational analysis (i.e., Shrinking Spotlight Diffusion Model analysis) confirmed that self-relevance impacted the focusing of attention during decision-making. These findings highlight how self-relevance modulates attentional processing.

Keywords: self, visual attention, spotlight, attentional breadth, flanker task.

That's Me in the Spotlight:
Self-Relevance Modulates Attentional Breadth

Prominent accounts of social-cognitive functioning advance a common prediction. In a complex world, as is the case for other potent classes of information (e.g., threating, novel), personally meaningful stimuli are prioritized by visual attention (Conway & Pleydell-Pearce, 2000; Humphreys & Sui, 2016; Oyserman et al., 2012; Sui & Rotshtein, 2019). As Sui and Rotshtein (2019) have remarked, "…self-related information acts as a global modulator of attentional processing" (p. 148). This, of course, is to be expected given the undoubted significance that self-relevant material holds in everyday life. What is therefore surprising is that, despite extensive research efforts, evidence supporting this viewpoint is scant. Although numerous studies have purported to demonstrate that attention is captured by self-relevant information (e.g., one's face/name vs. a friend's face/name; Bargh & Pratto, 1986; Gray et al., 2004; Shapiro et al., 1997), item familiarity provides a competing explanation for the reported effects.

To overcome this issue, recent research has adopted either shape-label matching or ownership tasks in which participants respond to arbitrary materials (e.g., circles, squares, pencils, pens) that have previously been associated with the self and various targets of comparison (e.g., friend, mother, stranger; Golubickis et al., 2018; Sui et al., 2012). Notwithstanding the use of inconsequential stimuli and the formation of temporary target-object associations, a robust finding has emerged in this work. Stimuli associated with the self (vs. others) are judged more rapidly during decisional processing; a phenomenon termed the self-prioritization effect (SPE) that has been replicated across different tasks, stimuli, and sensory modalities (e.g., Frings & Wentura, 2014; Golubickis et al., 2018; Macrae et al., 2018; Schäfer et al., 2015). Crucially, however, when it comes to attentional processing, self-prioritization has either failed to emerge or contradictory results have been reported (Liu & Sui, 2016; Macrae et al., 2017, 2018; Siebold et al., 2015; Stein et al., 2016; Wade & Vickery, 2018). Here then lies something of a conundrum. Despite widespread belief that attention prioritizes self-relevant stimuli, it remains to be seen whether this is the case.

Revisiting this core psychological topic, we similarly suspect that the personal significance of information is a pivotal driver of attentional selection (Humphreys & Sui, 2016; Sui & Rotshtein, 2019). Specifically, to optimize thinking and doing, we hypothesize that self-relevance moderates the breadth of visual attention, thereby regulating the influence that competing stimuli exert on decisional processing (Goodhew, 2020). Metaphorically, visual attention has been likened to a spotlight, with focal items selected for privileged processing at the expense of material residing outside the spotlight's glare (C. W. Eriksen & Hoffman, 1972; LaBerge, 1983; Posner, 1980). Furthermore, as a function of the prevailing task context, the resolution of the spotlight can be adjusted (i.e., narrow vs. wide), enabling attentional resources to be focused on a small region or distributed more sparsely over a larger area (C. W. Eriksen & St. James, 1986). This variation in attentional breadth has important implications for processing outcomes. Most notably, when attentional focus is narrow (vs. wide), the potentially disruptive impact of competing stimuli on decision-making can be minimized.

To demonstrate how attentional breadth influences processing, the flanker task has been a popular experimental tool (B. A. Eriksen & Eriksen, 1974). In this paradigm, responses must be made to a central target (e.g., >) that is flanked by compatible (e.g., > > > > >), incompatible (e.g., < < > < <), or neutral (e.g., - - > - -) stimuli that participants have been instructed to ignore. Of interest is the extent to which the ostensibly irrelevant flankers influence task performance. In this respect, failure of selective attention occurs when responses to the target are faster when it is flanked by compatible compared to incompatible items, the aptly named flanker compatibility effect. Using variants of this procedure, research has established that both person (e.g., induced emotional states) and stimulus-related (e.g., facial expressions) factors moderate attentional breadth (Fenske & Eastwood, 2003; Gable & Harmon-Jones, 2008, 2010; Huntsinger, 2012; Rowe et al., 2007). Generally speaking, stimuli that are noteworthy by dint of their intrinsic properties, salience, or goal-relevance narrow the focus of spatial attention, such that flanker compatibility effects are diminished or eliminated. By extension, this has obvious implications for self-referential processing. Given the supposed attentional prioritization of self-relevant material (Humphreys & Sui, 2016; Sui & Rotshtein, 2019), just such a shrinkage in spatial attention should take place when personally significant items comprise the to-be-judged targets in a flanker array, a possibility we explored in the current investigation.

Using a standard flanker paradigm, here we considered the extent to which self-relevance modulates the breadth of attention during decisional processing. Following extant work, self-target associations were created and probed using the two methodologies that currently dominate research on self-prioritization. Specifically, one group of participants initially paired geometric shapes with self and a friend (i.e., shape-classification task; Sui et al., 2012), with the shapes subsequently serving as targets in arrays combined with compatible, incompatible, or neutral flankers. In contrast, a second group initially learned that the computer had assigned an arbitrary object to be owned by self, with a different object belonging to a friend (i.e., object-ownership task; Golubickis et al., 2018). These objects then served as targets in compatible, incompatible, and neutral flanker displays. This between-participants manipulation was included to establish the replicability and generality of the effects of interest. Across both judgment tasks, self-relevance was expected to modulate the breadth of spatial attention, such that the flanker compatibility effect would be attenuated (or abolished) when self-related (vs. friend-related) stimuli comprised the to-be-judged targets. To confirm the origin of this effect (i.e., contraction of the attentional spotlight), an additional computational analysis — Shrinking Spotlight Diffusion Model analysis — was conducted on the data (White et al., 2011).

Method

Participants and Design

Sixty participants were recruited (39 female & 21 male, M_{age} = 22.54, *SD* = 2.87) using the Prolific platform for online testing (www.prolific.co), with each receiving compensation at the rate of £7.50/h. Informed consent was obtained from participants prior to the commencement of the experiment and the protocol was reviewed and approved by the Ethics Committee at the School of Psychology, University of Plymouth, UK. The experiment had a 2 (Target Association: self vs. friend) X 3 (Flanker: compatible vs. incompatible vs. neutral) X 2 (Task: shape-classification vs. object-ownership) mixed design with repeated measures on the first and second factors. Based on the medium effect sizes reported in prior research exploring self-prioritization using categorization tasks (Golubickis et al., 2018), a sample of 30 participants per judgment task afforded 85% power to detect an effect of $\eta_p^2 = .06$ (PANGEA v0.2).

Stimulus Materials and Procedure

Participants were randomly assigned to either the shape-classification or object-ownership task. Prior to the commencement of the experiment, participants in the shape-classification condition were told the computer would arbitrarily assign one of three geometric shapes (i.e., circle, triangle, square) to denote them, with one of the remaining shapes representing their best friend (Sui et al., 2012). They then pressed spacebar on the keyboard and the screen displayed which shapes designated self and friend, respectively (e.g., you are a circle, friend is a triangle). In contrast, participants in the object-ownership condition were initially told the computer would arbitrarily assign one of three objects (i.e., pen, mug, notebook) to be owned by them, with one of the remaining objects belonging to their best friend (Golubickis et al., 2018). They then pressed spacebar on the keyboard and the screen displayed which objects were self-owned and friend-owned, respectively (e.g., self owns pen, friend owns mug). The assignment of shapes/objects to the self and friend were counterbalanced across participants in each of the tasks and the stimuli were not presented during this learning phase. Further instructions explained that participants would be presented with a row of three shapes/objects (i.e., a central target and two flankers) and their task was simply to indicate, via a button press as quickly as accurately as possible, whether the middle shape/object represented (or was owned by) self or friend. To minimize distraction, they were instructed to ignore the flanking items. Responses were given using two keys on the keyboard (i.e., N and M) and the key-response mappings were counterbalanced across participants.

Each trial began with the presentation of a central fixation cross for 500 ms, followed by a row of three items (i.e., target & flankers) which remained on the screen until a response was made within a response window of 2000 ms. There were three types of flanking stimuli: the two shapes/objects previously associated with self and friend; and the third unassigned (i.e., neutral) shape/object. Thus, on each trial, the target was flanked by two compatible, incompatible, or neutral flankers (see Figure 1). The stimuli comprised grayscale images of geometric shapes (i.e., circle, triangle, square) and objects (i.e., pen, mug, notebook) that were 174 x 174 pixels in size and presented on a white background. In each judgment task (i.e., shape-classification or object-ownership), participants initially performed 12 practice trials, followed by six blocks of 60 experimental trials (i.e., 360 trials in total). The order in which the trials were presented within each block was randomized. On completion of the experiment, participants were thanked and debriefed.

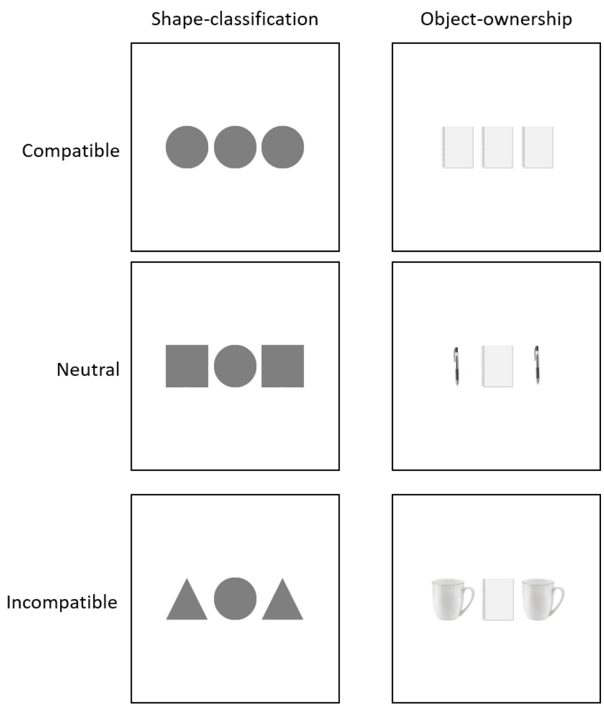

Figure 1. Examples of the stimulus displays in each judgment task (left panel – shape-classification task, right panel – object-ownership task).

Results

Responses faster than 200 ms and timed out trials were excluded from the analysis, eliminating less than 1% of the overall data. Seven participants (2 male) were excluded due to excessive error rates (> 50%). A 2 (Target Association: self vs. friend) X 3 (Flanker: compatible vs. incompatible vs. neutral) X 2 (Task: shape-classification vs. object-ownership) mixed model analysis of variance (ANOVA) was conducted on participants' mean correct response times (RTs) and response accuracy (see Supplemental Materials for a listing of the treatment means).[1]

The analysis of RTs yielded a main effect of Flanker ($F(2, 102) = 11.74$, $p < .001$, $\eta_p^2 = .187$) and significant Target Association X Flanker ($F(2, 102) = 5.14$, $p = .007$, $\eta_p^2 = .092$) and Target Association X Task ($F(1, 51) = 5.93$, $p = .018$, $\eta_p^2 = .104$) interactions. The Target Association X Flanker X Task interaction was not significant ($F(2, 102) = 1.86$, $p = .161$). Further analysis of the critical Target Association X Flanker interaction (see Figure 2) revealed a standard flanker interference effect (i.e., compatible < neutral < incompatible) when the target stimuli were associated with a friend ($F(2, 104) = 14.79$, $p < .001$, $\eta_p^2 = .221$). In contrast, no such effect emerged when the targets were associated with the self ($F(2, 104) = 1.93$, $p = .150$). Calculation and comparison of the observed flanker compatibility effects (i.e., incompatible condition minus compatible condition) revealed higher levels of flanker interference when the targets were associated with a friend compared to the self (respective *M*s: 20 ms vs. 7 ms; $t(52) = 2.89$, $p = .006$, $d = .40$).

A 2 (Target Association: self vs. friend) X 3 (Flanker: compatible vs. incompatible vs. neutral) X 2 (Task: shape-classification vs. object-ownership) mixed model ANOVA on the accuracy of responses yielded no significant effects (overall accuracy: $M = 94\%$). Given the elimination of flanker interference when self-related (vs. friend-related) stimuli comprised the targets of judgment, these findings demonstrate that self-relevance facilitated the contraction of spatial attention during decisional processing.

[1] Data are available at the OSF at the following link: https://osf.io/362rm/

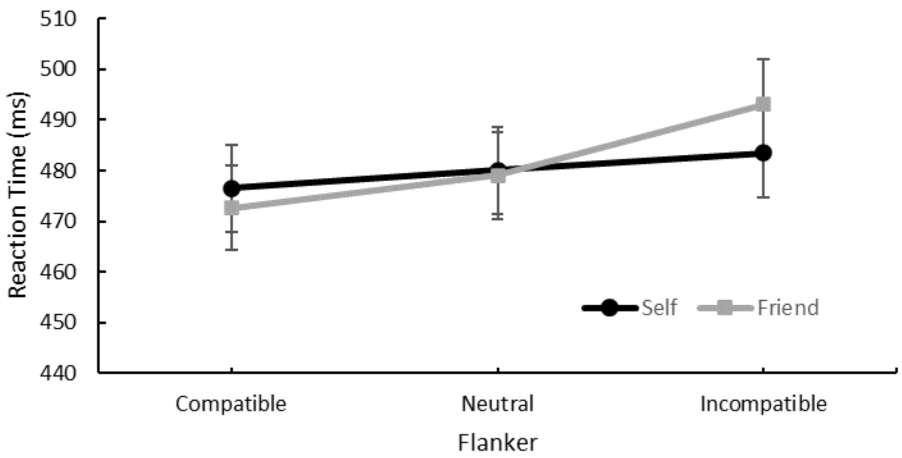

Figure 2. Mean response time (ms) as a function of Target Association and Flanker. Error bars represent +/-1 SEM.

Shrinking Spotlight Diffusion Model Analysis

To confirm the origin of the observed flanker effects, data (RT & accuracy) were submitted to an additional Shrinking Spotlight (SSP) Diffusion Model analysis (White & Curl, 2018; White et al., 2011). The SSP is an extension of the Drift Diffusion Model (DDM) of decision-making and was developed to elucidate the cognitive operations that underpin performance during flanker tasks (White et al., 2011). The model assumes that information is continually sampled from a stimulus until sufficient evidence has been accumulated to make a response (i.e., reach one of the decision thresholds). A primary strength of the model is that is able to account for changes in both response time and accuracy simultaneously. Departing from the standard DDM, a central assumption of the SSP is that the accumulation of decisional evidence (i.e., termed the drift rate) varies over time as a function of how attention is allocated during the task. That is, the resolution (i.e., width) of the attentional spotlight moderates task performance. Early in the task attention is diffuse, such that flankers contribute significantly to the drift rate. As time progresses, however, through shrinkage of the spotlight, attention focuses more narrowly on the target, thereby reducing flanker interference. The SSP captures the rate of this contraction (White et al., 2011).

The SSP parameters associated with the latent cognitive operations underpinning task performance include boundary separation (*a*), perceptual strength (*p*), non-decision time (*Ter*), spotlight width (sd_a), and shrinking rate (r_d). Boundary separation (*a*) estimates the distance between the two decision thresholds, thus indicates how much evidence is required before a response is made (i.e., larger [smaller] values indicate more conservative [liberal] responding). Perceptual strength (*p*) reflects the efficiency of visual processing (i.e., the perceptual contribution each stimulus makes toward faster decision-making), such that large (vs. small) values signal more rapid information uptake. The duration of all non-decisional processes is given by the *Ter* parameter, which indicates differences in stimulus encoding and response execution. Finally, the spotlight width (sd_a) and the shrinking rate (r_d) parameters collectively index attentional control during the task. Specifically, at the start of a trial, the sd_a estimates the initial distribution of attention, and r_d represents the speed at which the spotlight narrows on the central target. In combination, these parameters reveal that robust attentional control is facilitated by a focused spotlight and/or rapid shrinking rate (White et al., 2011).

To estimate the parameters of the SSP, data (i.e., RT quantiles and accuracy) were submitted to the fitting procedure adopted by White and Curl (2018). Apart from the spotlight width (sd_a), all parameters (*a*, *p*, *Ter*, s_d) varied as a function of Target Association (i.e., self vs. friend) and were fitted separately for each participant (see Supplemental Materials for a listing of the parameter estimates). The spotlight width (sd_a) was fixed at a value of 1 (Servant & Evans, 2020). To simplify parameter estimation, following White and Curl (2018), data from neutral flanker trials were not included in the model fitting procedure. As such, the SSP parameters for each participant and Target Association reflect the best fitting estimates for both compatible and incompatible trials simultaneously (White et al, 2011). The quality of model fit was evaluated by simulating data sets from the estimated parameters and then comparing these with the observed data. With nearly complete overlap between the simulated estimates and observed values, this demonstrated good model fit (see Figure 3).

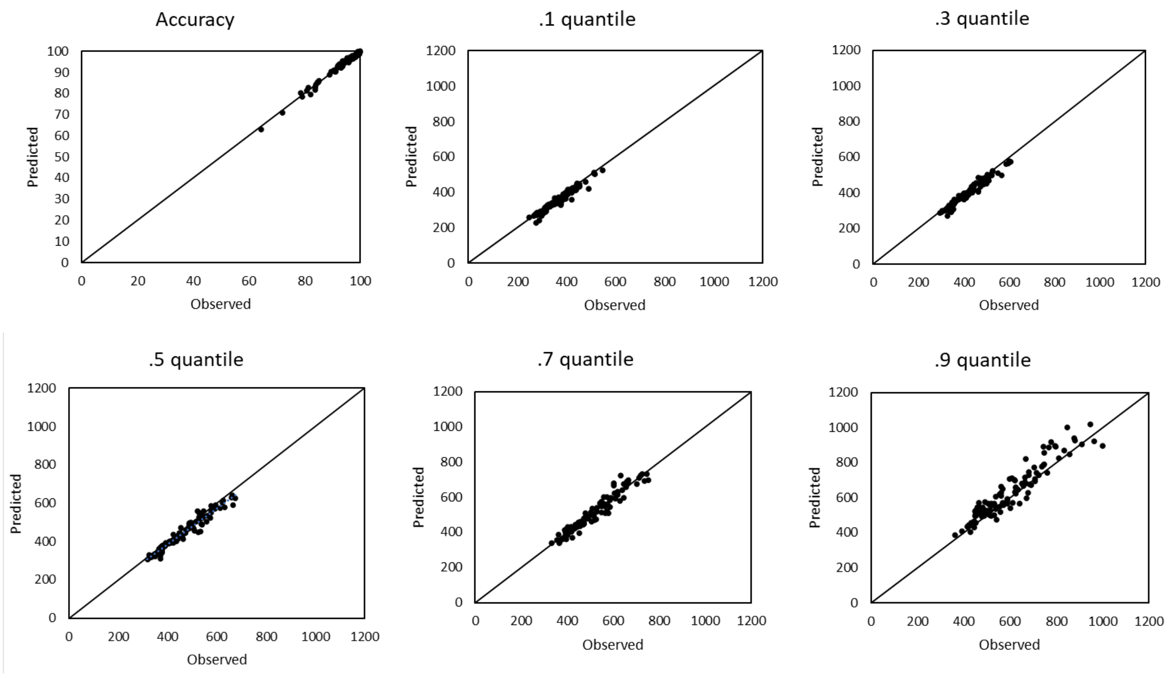

Figure 3. Fit quality from the SSP analysis. Observed responses are plotted against predicted responses from the best fitting SSP parameters for accuracy (%) and the RT quantiles (ms).

A 2 (Target Association: self vs. friend) X 2 (Task: shape-classification vs. object-ownership) mixed model ANOVA, with repeated measures on the first factor, was conducted on the SSP parameters. One participant (female) was excluded from the analysis due to failure during the estimation procedure. The analysis yielded no significant effects on estimates of boundary separation (*a*) or perceptual strength (*p*). For non-decision time (*Ter*), a significant Target Association X Task interaction was observed ($F(1, 50) = 4.79$, $p = .033$, $\eta_p^2 = .087$). Further analysis of the interaction revealed that non-decisional processes were faster for self-relevant (*M* = 275 ms, *SD* = 56 ms) compared to friend-relevant (*M* = 294 ms, *SD* = 58 ms) targets when the stimuli were objects ($F(1, 26) = 7.27$, $p = .012$, $\eta_p^2 = .219$). No such effect emerged when the stimuli were shapes ($F(1, 24) = 0.115$, $p = .737$). The efficiency of attentional control was evaluated by calculating the ratio between the spotlight width and shrinking rate parameters (i.e., sd_a/r_d). The resulting measure captures the interference time, specifically the time needed to focus attention fully on the target in the stimulus array, with smaller (vs. larger) values indicating a better ability to engage selective attention and reduce flanker interference. (White et al., 2011). Analysis of this parameter yielded only a main effect of Target Association ($F(1, 50) = 7.85$, $p = .007$, $\eta_p^2 = .136$), indicating that less time was needed to focus attention (i.e., shrink the spotlight) when responding to self-relevant ($M = 250$ ms, $SD = 62$ ms) compared to friend-relevant ($M = 287$ ms, $SD = 99$ ms) targets. This confirms that self-relevance facilitated attentional control (see Figure 4).

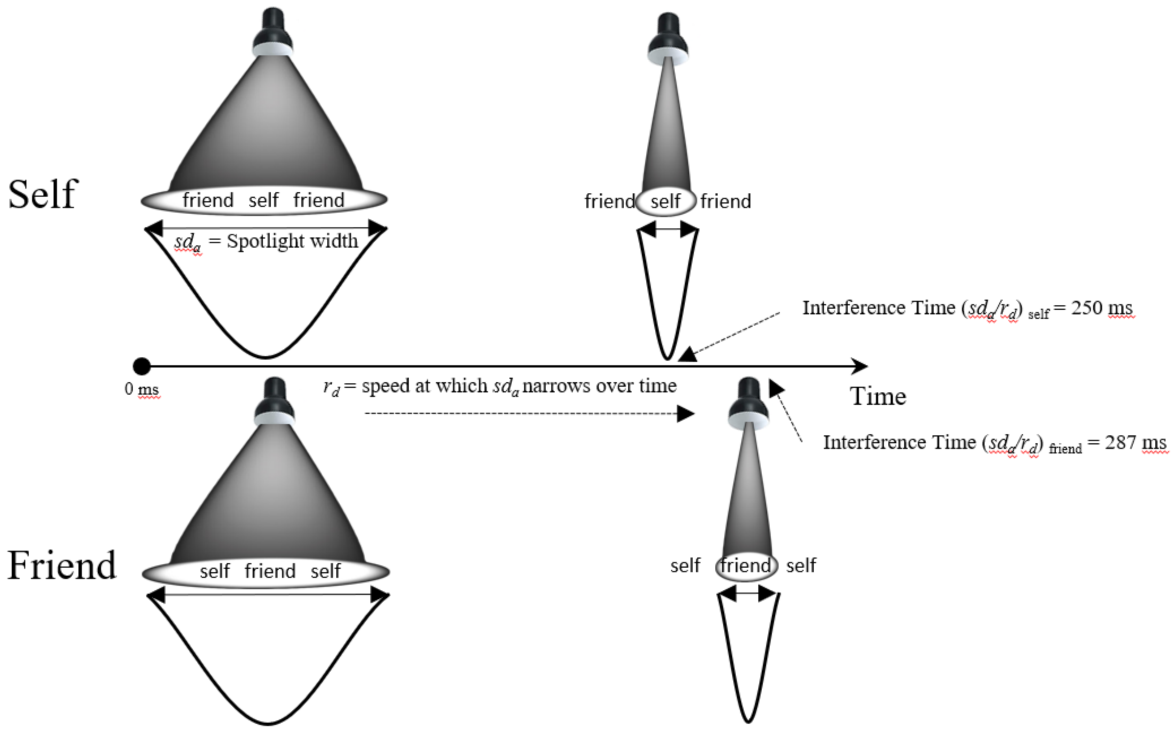

Figure 4. Schematic depiction of the shrinking spotlight effect as a function of Target Association. The arrows indicate the time taken to focus attention on the target.

General Discussion

Using a flanker paradigm and two judgment tasks commonly employed to explore self-prioritization (i.e., shape-classification & object-ownership), here we demonstrated that self-relevance modulated the breadth of spatial attention during decisional processing. Whereas a standard flanker compatibility effect was observed when friend-related items comprised the targets of interest, flanker interference was eliminated when self-related stimuli were the to-be-judged items. Corroborating the prediction that variation in the distribution of attentional resources underpinned this difference in task performance, an additional computational analysis (i.e., SSP diffusion model; White et al., 2011) revealed that self-relevance moderated the breadth of visual attention.

The benefits of an attentional system that is finely tuned to self-relevant inputs are considerable. In navigating the complex task settings in which interpersonal exchanges typically occur, prioritizing material that is highly goal-relevant — as is routinely the case with self-related stimuli — affords numerous advantages. Specifically, attentional prioritization increases not only the salience and memorability of personally relevant information, but also the ability to act upon this material (Constable et al., 2011; Symons & Johnson, 1997). Of course, that such benefits emerge for overlearned stimuli (e.g., one's face and name) is unsurprising (Bargh & Pratto, 1986; Gray et al., 2004; Shapiro et al., 1997). Crucially, however, as demonstrated here, attentional prioritization also extends to entirely arbitrary material that has been linked with the self. Moreover, whether these stimuli comprise proxies for the self or allegedly self-owned objects (Golubickis et al., 2018; Sui et al., 2012) information processing takes a similar course — self-relevance (vs. friend-relevance) moderates attentional selection (Humphreys & Sui, 2016; Sui & Humphreys, 2015).

A primary objective of the current inquiry was to identify the pathway through which self-relevance influences attentional processing. Applying a bespoke computational analysis for just this purpose (i.e., SSP diffusion model analysis), the results demonstrated that personally meaningful targets enhanced task performance by narrowing the breadth of attention, thereby eliminating flanker interference effects. That is, based on the assumption that reduced flanker interference reflects greater shrinkage of the attentional spotlight on the to-be-judged item (C. W. Eriksen & St. James, 1986), the current findings demonstrated that, compared to friend-related targets, self-related targets facilitated the constriction of spatial attention. Importantly, this highlights the value of computational modeling in explicating the cognitive mechanisms that underpin patterns of performance (i.e., RT & accuracy) in conflict tasks, such as the flanker paradigm (Servant & Evans, 2020; White et al., 2011). Although previous work has claimed that certain affective states (e.g., negative moods) and classes of stimuli (e.g., negative emotional expressions) narrow attentional focus (e.g., Fenske & Eastwood, 2003; Gable & Harmon-Jones, 2008, 2010), absent measures of process specificity, it was not possible to establish the veracity of this conclusion. Critically, application of the SSP (or related models - e.g., Diffusion Model for Conflict Tasks; Servant & Evans, 2020) yields precisely this level of insight into the determinants of task performance.

It should of course be noted that narrowing of the spotlight of attention yielded lower levels of flanker interference when to-be judged targets were self-relevant compared to friend-relevant. While emphasizing the ease with which self-relevant targets capture attention, it is also possible that self-relevant flankers influenced attentional processing. That is, just as it was easier for participants to direct attention to self-relevant (vs. friend-relevant) targets, so too it was harder for them to disengage attention from self-relevant (vs. friend-relevant) flankers. As such, either (or indeed both) of these effects may have contributed to the emergence of the current results. A useful task for future research will be to explore this issue further. In addition, it is also important to acknowledge recent debate around the conditions under which self-relevance facilitates task performance. For example, when comparing attentional and decisional processing, Schäfer and colleagues (2020) demonstrated that although self-relevant stimuli failed to capture attention, a SPE nevertheless emerged. Of significance is likely the goal relevance of stimuli in different experimental contexts. In particular, when requested judgments do not make salient (or explicitly rely upon) previously learned self-object associations in working memory (Sui et al., 2012), self-relevance does not influence task performance (Caughey et al., 2021; Constable et al., 2019; Falbén et al., 2019; Schäfer et al., 2020; Stein et al., 2017).

In expanding the scope of the current inquiry, future research should consider the nuanced effects that self-relevance undoubtedly exerts on attentional prioritization (Coleman & Williams, 2015; Conway & Pleydell-Pearce, 2000; Golubickis et al., 2020). On a moment-by-moment basis, information is associated, not with a generic representation of the self, but rather with contextually relevant sub-components of the self-concept — specifically, personal identities — that access working memory and guide behavior in a flexible, dynamic manner (McConnell, 2011; Oyserman et al., 2012). The implications for attentional selection are obvious. Whether objects (e.g., raspberry cheesecake) narrow the focus of attention in any given setting will likely be determined by which of a person's myriad identities (e.g., dessert lover vs. dieter) is activated at that particular point in time. In other words, the identity-related relevance of stimuli should regulate the breadth of attention, hence attendant processing outcomes.

In summary, using a flanker task in combination with the SSP diffusion model analysis, here we demonstrated both the attentional prioritization of personally meaningful stimuli and the cognitive origin of this effect. In so doing, the current effects affirm the fundamental influence that self-relevance exerts during attentional processing (Humphreys & Sui, 2016; Sui & Humphreys, 2015).

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