Does Motivational Intensity Exist Distinct from Valence and Arousal?

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Abstract

The motivational intensity model proposes that the strength of one's urge to approach or avoid a stimulus is the primary driver of cognitive broadening/narrowing (Gable & Harmon-Jones, 2010d; Harmon-Jones, Gable, & Price, 2012). However, it is unclear whether motivational intensity is truly distinct from well-established dimensions of valence and arousal. Here we found an overwhelmingly strong relationship between motivational intensity and valence across all studies. In Study 1, we operationalised motivational intensity on two response rating scales and had multiple groups of participants (total 150) rate their response of motivational intensity, valence, and arousal to 300 pictures. There was a very strong relationship between motivational intensity and valence (r_s in excess of .9, in studies 1a and 1b), which challenges the idea that these two constructs are distinct. In contrast, motivational intensity ratings were not consistently positively related to arousal ratings, with only a moderate relationship found with avoidance motivation. In Study 2 we used an implicit measure of motivational intensity and valence and asked participants to classify their motivational intensity and valence in response to 100 pictures from Study 1. A high degree of correspondence was found between motivational intensity and valence on this measure. Overall, our findings are at odds with proposals in the literature that arousal can be used as a proxy for motivational intensity across the full approach-avoidance spectrum. Furthermore, these studies suggest that the cognitive effects attributed to motivational intensity in previous literature are best explained by valence.

Keywords: valence; arousal; motivational intensity; approach; avoidance.

Does Motivational Intensity Exist Distinct from Valence and Arousal?

The factors that drive cognitive processes have been the subject of psychological research for over 50 years. Several key theories argue emotions have a key role to play in the broadening/narrowing of cognitive scope (for a review, see Harmon-Jones, Gable, et al., 2012). Here we use cognitive scope as an umbrella term to cover multiple cognitive processes (e.g., attentional breadth, memory, time perception, cognitive categorization, and visual perception; (e.g., Fredrickson, 1998; Fredrickson & Branigan, 2005; Rowe, Hirsh, & Anderson, 2007). Proposals include that negative emotions narrow cognitive scope (Finucane, 2011) and positive emotions broaden cognitive scope (Fredrickson, 1998; Fredrickson & Branigan, 2005). These theories focus on the dimension of valence. That is, an individual's subjective experience ranging from unpleasant/negative to pleasant/positive. More recently however, the motivational intensity model has been proposed as an alternative dimension that might better explain the changes that occur in cognitive processing under different emotional conditions (e.g., Gable & Harmon-Jones, 2010a, 2010d; Harmon-Jones & Gable, 2008; Harmon-Jones, Gable, et al., 2012; Harmon-Jones, Gable, & Price, 2013). Motivational intensity is defined as the strength of urge to move towards or away from a stimulus (Harmon-Jones, Price, & Gable, 2012). Proponents of this model claim that previous studies focused on valence exclusively examined positive emotions low in motivational intensity (e.g., contentment and amusement) and negative emotions high in motivational intensity (e.g., disgust), and that the distinguishable cognitive outcomes from these different-valence conditions can therefore be attributed to confounding differences in the motivational intensity instead of valence (Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2008a, 2010a). The main claim of the motivational intensity account of cognitive processing is that high motivational intensity—irrespective of whether the urge is to approach or avoid—narrows cognitive scope (for reviews, see Harmon-Jones, Gable, et al., 2012; Harmon-Jones et al., 2013). The broadening and narrowing of

cognitive scope may occur at many levels. It has measured by the broadening and narrowing of attentional breadth, memory, time perception, cognitive categorisation, and visual perception (Gable & Harmon-Jones, 2010a, 2010d; Gable & Poole, 2012; Rowe et al., 2007; Threadgill & Gable, 2019). This idea derives from functional arguments. For example, if a person feels a strong desire to approach a stimulus (e.g., a dessert) then it makes sense that they should narrow their attentional focus (one measure of cognitive scope) to 'zero in' on pursuing the dessert. Alternatively, if a person feels a strong desire to avoid a stimulus (e.g., a snake) then focusing narrowly on it could facilitate that avoidance. In contrast, when an individual feels contentment (e.g., after consuming a dessert), they no longer have a strong goal or urge to act, and accordingly their attentional breadth would broaden.

While this idea has strong intuitive appeal, the literature is unclear about how motivational intensity should be operationalised. For example, it is suggested that arousal is an appropriate rough proxy for motivational intensity (e.g., Gable & Harmon-Jones, 2008a, 2010a, 2013). However, the extent to which motivational intensity is distinct from other established dimensions, such as valence and arousal, is questionable. This is important because a pre-requisite for motivational intensity to have additional explanatory power is that it needs to be distinct from established dimensions. Here, we examine two alternative ways of operationalising motivational intensity using rating scales that ask people explicitly about their urge to approach or avoid. We then measure motivational intensity implicitly using an RT-based measure. Both types of tasks are used to test whether motivational intensity is truly something distinct from valence and arousal.

The Valence-Arousal Model of Emotions, and Cognitive Processing

The architecture of emotion is conceptualised as consisting of two key dimensions: valence and arousal (Bradley & Lang, 2007a; Russell, 1980). Valence is conceived of as varying from unpleasant/negative to pleasant/positive via a neutral midpoint, and arousal as

varying from low (e.g., calm) to high (e.g., excited/agitated). These dimensions are dissociable, though not entirely independent. That is, emotions with extreme valences, either positive or negative, score higher in arousal, producing a U-shaped function when elicited emotions are plotted as a function of valence (x-axis) and arousal (y-axis).

There is a long history of theories using these two dimensions to explain the relationship between emotions and a number of cognitive processes. People's experience of emotion has demonstrated associations with a variety of cognitive processes, including attentional breadth and visual perception (e.g., Easterbrook, 1959; Finucane, 2011; Finucane & Power, 2010; Fredrickson & Branigan, 2005; Friedman & Förster, 2010; Johnson, Waugh, & Fredrickson, 2010). Some early theoretical accounts proposed that emotional arousal narrows cognitive scope (Easterbrook, 1959). Others have espoused that all negative-valence emotional states narrow cognitive scope (Finucane, 2011; Finucane & Power, 2010). A more recent, popular proposal is the *broaden-and-build hypothesis*, which posits that all positive affective states broaden cognitive scope (Fredrickson, 1998; Fredrickson & Branigan, 2005).

Motivational Intensity as an Alternative Mediator of Cognitive Processing

Over the last decade, research on emotion and cognitive scope has looked to the motivational intensity model for a potentially better account of observed effects (Gable & Harmon-Jones, 2010a, 2010d; Harmon-Jones & Gable, 2008; Harmon-Jones, Gable, et al., 2012; Harmon-Jones et al., 2013). For instance, the motivational intensity model has been studied in relation to attentional breadth (e.g., Gable & Harmon-Jones, 2008a, 2010a), which is the spatial area over which attention is deployed (Eriksen & St. James, 1986; Goodhew, 2020). The motivational intensity model predicts that emotions that are positive or negative in valence but high in motivational intensity (e.g., desire = high approach, disgust = high avoid) narrow attentional breadth, and that emotions that are positive or negative valence, but low in motivational intensity (e.g., amusement and sadness = low approach) broaden it (e.g., Gable &

Harmon-Jones, 2008a, 2010a; Harmon-Jones et al., 2013). Here the driver of attentional breadth is the strength of motivational intensity, irrespective of the valence. Indeed, a critical theoretical point is that motivational intensity is claimed to be dissociable from valence (Carver & Harmon-Jones, 2009; Summerell et al., 2019) and arousal (Gable & Harmon-Jones, 2013).

Other studies have measured the impact of emotion on changes of cognitive scope using the broadening and narrowing of memory (e.g., Gable & Harmon-Jones, 2010b; Threadgill & Gable, 2019) and the shortening and lengthening of time perception (e.g., Gable, Neal, & Poole, 2016; Gable & Poole, 2012). For instance, it has been claimed that strong motivational intensity enhances memory for centrally presented targets, and low motivational intensity enhances memory for peripherally presented targets (Threadgill & Gable, 2019). Motivational intensity is also claimed to be important in explaining the effect of emotion on other cognitive processes, such as cognitive categorization and attentional flexibility (e.g., Ma & Li, 2016; Price & Harmon-Jones, 2010) Altogether, this suggests that motivational intensity models may better explain the observed relationships between emotion and cognitive processes than valence or arousal-based theories.

Problems with the Operationalisation of Motivational Intensity

Given the theoretical importance of motivational intensity, it is striking that little work has investigated the most appropriate way to operationalise it. Gable and Harmon-Jones have tended to rely on two approaches, both of which lack empirical backing. In some instances, they have recommended using arousal ratings as a proxy for motivational intensity, with higher arousal ratings being indicative of greater motivational intensity (Gable & Harmon-Jones, 2010a; Gable & Poole, 2012). This approach makes an untested assumption about how motivational intensity relates to arousal. It is also somewhat curious to insist that motivational intensity is conceptually distinct from arousal (Gable & Harmon-Jones, 2010a; Harmon-Jones et al., 2013), yet to recommend it as an appropriate method of operationalising the construct

(Gable & Harmon-Jones, 2010a; Gable & Poole, 2012; Harmon-Jones, Gable, et al., 2012; Threadgill & Gable, 2019).

In other instances, Gable and Harmon-Jones have used ratings of discrete emotions (e.g., level of amusement) to operationalise motivational intensity, based on assumptions about how these discrete emotions relate to motivational intensity (e.g., that amusement = low motivational intensity). These assumptions are based on logical analysis and face validity, but typically lack corroborating evidence (Gable & Harmon-Jones, 2008a, 2008b, 2010a, 2010c; Harmon-Jones & Gable, 2009).

Similar assumptions that lack substantiating evidence pervade the research linking motivational intensity to asymmetries in frontal cortical activation, measured via electroencephalogram (EEG). Early work on frontal cortical activation linked negative and positive emotions with preferential activation of the right and left frontal cortices respectively (Gainotti, 1972; Robinson & Price, 1982). Historically, observed frontal asymmetries have been attributed to the *valence* of emotion experienced. However, proponents of the motivational intensity model argue motivational direction rather than valence drives these asymmetries. That is, that approach motivation (rather than positive valence) leads to preferential left activation (Harmon-Jones & Gable, 2018; Harmon-Jones, Gable, & Peterson, 2010). The key assumption underlying this reasoning is that anger, despite its negative valence, elicits approach motivation – an assumption that remains minimally tested, and uncorroborated by the evidence obtained.

One emotion often held up as a logical example of motivational intensity disconnecting from valence is anger. Anger is a negative valence emotion that is claimed to be approach-motivated (for a review, see Carver & Harmon-Jones, 2009). Recently, Gable, Poole, and Harmon-Jones (2015) conducted four studies to assess the effect of anger and therefore motivational intensity on cognitive scope, and collected participant ratings of motivational

intensity in only the fourth study. Here, they compared responses to an angry and a neutral film, and participants rated the angry and neutral film equivalently with respect to their motivational intensity. This challenges the claim that anger is associated with approach motivation. In spite of this Gable et al. (2015) still interpreted their behavioural results as stemming from the differential motivational intensity of these conditions. The differential behavioural results suggest that the conditions do differ in some way. However, we believe it is problematic to attribute this to their motivational intensity in light of the ratings data.

Similarly, Gable et al. (2016, Experiment 5) studied the influence of anger on time perception. Participants in two conditions both watched a film designed to induce anger. Participants in both conditions gave mean ratings indicative of strong avoidance rather than approach motivation (6.82 and 7.05 for the two conditions that both watched the same film, on a scale that ranged from 1 = move toward to 9 = move away). This suggests that the assumption that anger is associated with approach motivation is problematic. To our knowledge, these are the only two studies to have collected ratings of motivational intensity following an anger induction, and neither support the claim that anger is an approach-motivated state. Therefore, this casts doubt on the claim motivational intensity rather than valence is the key determinant of the frontal asymmetry as measured by EEG result, since this conclusion is based on the assumption that anger is associated with approach motivation. Despite this, as recently as 2018, the proponents of the motivational intensity account still offer this as an explanation for the observed frontal asymmetries (see Harmon-Jones & Gable, 2018). This highlights the continued currency of motivational intensity as a construct for explaining observed effects of emotion on brain and behavioural responses, and the urgent need for rigorous approaches to its operationalisation.

Overall, both of these approaches to operationalising motivational intensity make assumptions that have not been subject to systematic testing or validation to confirm that

participants consider the stimuli as having the motivational intensity that the researchers attribute, and when small-scale testing (e.g., responses to a single film) has been conducted, it often contradicts the researchers' claims. Furthermore, the proponents of motivational intensity have not examined the association between motivational intensity and valence and arousal, which we believe is a prerequisite for recommendations about potential proxies.[1]

To summarise, motivational intensity appears to be an important and influential theoretical construct, but what is needed is a stronger basis for operationalising it in experiments on the emotion-cognition nexus, including a greater understanding of how it relates to established dimensions such as valence and arousal. This is what we did in the present study. The following section critically examines in more detail the potential structure of motivational intensity.

How Should Motivational Intensity be Operationalised?

The definition of motivational intensity (i.e., the urge to move towards/away from a stimulus; (Harmon-Jones, Gable, et al., 2012) suggests that a single dimension is the current accepted structure of motivational intensity, implying it should be measured on a single rating scale. However, this dimensional singularity has never been empirically verified. It is possible that motivational intensity has a dual-structure, whereby approach motivation and avoidance motivation are partially dissociable and should be measured separately. For instance, some stimuli might elicit strong avoidance *and* approach urges: a picture of a person with a deep cut on their leg might elicit a strong urge to avoid because the stimuli is unsettling to look at (Gable & Harmon-Jones, 2010a), but at the same time it may elicit a strong urge to approach to help.

[1] It is worth acknowledging that the Nencki Affective Picture System (NAPS) is the only picture database whereby ratings of motivational direction have been collected for picture stimuli (Marchewka, Żurawski, Jednoróg, & Grabowska, 2014). While this is a useful and important first step, their goal was to create a modernised picture database for use in emotional research. This means that the authors did not critically evaluate the conceptualisation, structure, and operationalisation of motivational intensity. Here, our goal was to do this.

Using a single dimension would make it impossible to capture both of these responses. To test whether it is important to measure the urges to approach and avoid separately, Study 1a used two separate scales for these ratings. However, approach and avoidance ratings were very strongly inversely correlated, consistent with motivational intensity existing on a single dimension. Study 1b therefore collected ratings of motivational intensity on a single bidirectional scale, with avoidance at one end and approach at the other.

The Present Approach

The present work had three primary aims. The first aim was to establish an appropriate method for operationalising motivational intensity, using different types of rating scales. The second aim was to compare motivational intensity with established constructs of emotion, by assessing how ratings of motivational intensity associated with traditional measures of valence and arousal. The third was to assess whether the pivotal relationships observed were also obtained on an implicit measure. A key aspect of this work was to rigorously test the extent to which motivational intensity is distinct from valence and arousal. If motivational intensity is distinct from these established dimensions, then we would expect to see areas of dissociation in their measurement. In Study 1a, we measured approach and avoidance motivation separately, both ranging from low to high. Study 1a also collected ratings of arousal, from calm to aroused, and valence, from unpleasant to pleasant via a neutral mid-point (i.e., a bidirectional scale). In Study 1b, we operationalised motivational intensity on a single bidirectional scale, which ranged from avoid to approach via a neutral mid-point. Ratings of motivational intensity from both studies were then compared with ratings of valence and arousal from Study 1a. Finally, in Study 2, pictures that reflected the full range of motivational intensity ratings from Study 1b were used in a paradigm which used RT in a classification task to provide implicit measures of motivational intensity and valence.

Study 1a: Separate Measurement of Approach Motivation and Avoidance Motivation

In Study 1a, participants looked at 300 different photographic pictures and rated how much they felt an urge to approach/avoid, or unpleasant/pleasant, or aroused in response. Because Study 1a and all subsequent studies analyses used mean ratings for individual picture stimuli, not individual participants, the appropriate sample for power analysis is the number of pictures, not participants. To achieve power of 0.8 for a medium effect (r = 0.5) with α = .05 we required N = 29 (calculated with G*Power, Faul, Erdfelder, Buchner, & Lang, 2009; Faul, Erdfelder, Lang, & Buchner, 2007). Thus, our sample size of 300 picture stimuli in Study's 1a and 1b, and 100 picture stimuli in Study 2 exceeded the required power. Note, the large number of pictures was selected to ensure comprehensive representation along all parts of the dimensions under study. Further, evidence suggests that for stable mean ratings, the minimum number of *participants* needed is 20 (DeBruine & Jones, 2018). We had 30 participants performing the ratings on each dimension, and therefore clearly satisfied this criterion. The pictures were 250 pictures from the International Affective Picture System (IAPS) database (Lang, Bradley, & Cuthbert, 2008) and 50 royalty-free pictures from the Internet similar in nature to those used in previous research on motivational intensity. We had participants rate their motivational intensity on separate approach and avoidance motivation scales so that we could assess whether motivational intensity has a single or dual dimension structure. If the urges to approach and avoidance are related but dissociable, then the correlation between them ought to be modest.

Method

Participants. One-hundred-and-twenty participants (79 female, 40 male, 1 other) with ages ranging between 18 and 26 years (M_{age}= 19.33, SD_{age}= 1.52) who were recruited from the online Australian National University (ANU) SONA recruitment system for one course credit met the inclusion and recruitment criteria for the present study. We used visual stimuli (i.e.,

pictures), and therefore one participant recruitment criterion was that participants have normal or corrected-to-normal vision. A large proportion of stimuli may have had specific cultural meaning, and there are also cultural differences in reported emotional experiences, so therefore participant recruitment criteria included that participants were born and raised in a predominately Western identifying countries (e.g., Australia, New Zealand, United States of America, United Kingdom, Canada, or the Republic of Ireland). Since the instructions were in English and required a relatively nuanced understanding of different aspects of emotion described therein, we also required that participants were native English speakers. We also wanted responses to reflect neuro-typical responses, therefore we enforced exclusion criteria for disorders known to affect cognitive and emotional processing. More specifically, participants were recruited on the basis that they reported no major neurological or psychiatric disorders (e.g., ADD/ADHD, Autism Spectrum Disorder, Schizophrenia, or major neurological illnesses requiring hospitalisation). Further, whole cases were removed if they had missing data over 5% (>15) of picture ratings. This and all subsequent studies were conducted in compliance with a protocol (2019/162) approved by the ANU Science and Medical Delegated Ethical Review Committee. Participants provided informed consent prior to commencement of the study. We included questions which screened to check that participants had complied with the above recruitment criteria, and they were excluded from further analysis if they failed to meet any of the above criteria.

Stimuli: demographic and debriefing questionnaires. General demographic and background information were gathered from participants in this and all subsequent studies to characterise the sample and to ensure compliance with the recruitment criteria. The demographic and background questions included age, sex, dominant handedness, country of birth, country spent the most time in, first language, normal or corrected-to-normal vision, and the presence of any major neurological or psychiatric disorders. The experiment was conducted

fully-online via Qualtrics, and participants were instructed to resize their screen to 100% viewing size to ensure that the picture and rating scale resolution was appropriate for participants' computer, mobile, or tablet screen.

Participants were also asked to complete debriefing questions at the end of the experiment. The debriefing questions included an indicator of how much effort participants put into the ratings, possible explanations for why they may not have put as much effort as they could have while rating the pictures (e.g., tired or sick), whether they generally eat and enjoy desserts (given that dessert pictures were included, consistent with Gable and Harmon-Jones (2010c); Harmon-Jones and Gable (2009)), and whether they had eaten in the previous two hours. Participants gave responses about how much effort they put into the ratings ranging from 1 (*no effort*) to 10 (*maximum effort*), the average response was 8.02 (*SD* = 1.17, range: 4.00-10.00). In total, 82.5% of participants responded that they generally eat desserts, and 98.3% of participants indicated that they generally enjoy desserts. Moreover, 60% of participants had eaten within 2 hours prior to completing the questionnaire. None of the 120 participants were excluded from final analyses based on their debriefing questionnaire responses because they were not outliers on greater than 5% of picture ratings.

Stimuli: pictures and rating scales. Separate rating scales were used to operationalise valence, arousal, approach motivation, and avoidance motivation. Each participant rated all of the pictures on just one of the four dimensions. Each dimension was rated by an equal number of participants (n = 30). Participants only completed one rating scale to avoid response-scale contamination across dimensions. Thirty participants were recruited for each condition, as this exceeds the minimum number needed for stable mean ratings (DeBruine & Jones, 2018). For their allocated dimension, all participants rated 250 IAPS pictures and 50 royalty free pictures from the Internet.

IAPS pictures. A total of 250 pictures were selected from the IAPS database (Bradley & Lang, 2007b; Lang, Bradley, & Cuthbert, 1997; Lang et al., 2008) (see Appendix A for selected IAPS picture numbers). In previous research, each IAPS picture has been rated using the Self-Assessment Manikin (SAM) by approximately 100 participants for feelings of pleasure (i.e., valence, ranging from 1 (*unpleasant*) to 9 (*pleasant*), arousal, ranging from 1 (*calm*) to 9 (*excited*), and dominance, ranging from 1 (*dominated*) to 9 (*in-control*)) (Lang et al., 2008). These ratings have been subsequently validated by a variety of physiological measures that result from viewing the pictures (Bradley, Hamby, Löw, & Lang, 2007; Bradley & Lang, 2007a, 2007b; Codispoti, Ferrari, & Bradley, 2007; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Lang, Bradley, & Cuthbert, 1998).

The IAPS pictures for the present study were chosen to best represent the diverse range of pictures in the IAPS database. To achieve this diversity, five categories were created with different valence and arousal levels. These included 50 pictures from each category that represented: (1) high valence (M = 6.86, range: 6.00-8.02), high arousal (M = 6.56, range: 6.02-7.35); (2) high valence (M = 7.55, range: 7.00-8.34), medium arousal (M = 4.72, range: 4.00-5.83); (3) medium valence (M = 4.93, range: 4.23-5.61), low arousal (M = 2.68, range: 1.72-3.25); (4) low valence (M = 2.12, range: 1.45-2.96), high arousal (M = 6.48, range: 6.00-7.34); and (5) low valence (M = 2.50, range: 1.79-2.98), medium arousal (M = 5.14, range: 4.00-5.98). The reason that these five categories were used is that when pictures are rated high in arousal, they tend to have extreme (pleasant or unpleasant) valence ratings. That is, valence and arousal are not independent, and functionally there are not pictures that have high arousal and neutral valence or low arousal and extreme valence.

Royalty free pictures. A total of 50 royalty free pictures were collected to represent valence and arousal states that were not widely represented in the IAPS database, but that have been used in previous research on motivational intensity. Appendix A lists these pictures.

These included pictures of different cuisines (e.g., foods that are regarded 'desirable' in Western society, such as fast foods and desserts), and also pictures that represent amusement (e.g., pictures of cats in humorous situations, and pictures that represent amusing scenarios) (Gable & Harmon-Jones, 2008a; for a review, see Harmon-Jones, Gable, et al., 2012). In total, 12 Western cuisine pictures, 13 dessert pictures, 13 pictures of cats in humorous situations, and an additional selection of 12 pictures that were considered to best represented amusement were selected for presentation.

Valence ratings. Thirty participants (24 female, 6 male; M_{age} = 18.93, SD_{age} = .98, age range: 18-22) rated how unpleasant (negative) versus pleasant (positive) they felt in response to each picture from -4 (*unpleasant*) to +4 (*pleasant*), with 0 being labelled neutral (Figure 1a).

Arousal ratings. Thirty participants (18 female, 12 male; M_{age} = 19.67, SD_{age} = 2.06, age range: 18-26) rated pictures based on how calm (unaroused) versus aroused (excited) they felt while viewing the picture from 1 (*calm*) to 9 (*aroused*), with no neutral point labelled (Figure 1b).

Approach motivation ratings. Thirty participants (19 female, 11 male; M_{age} = 19.7, SD_{age}= 1.74, age range: 18-26) rated pictures based on the strength (low versus high) of their urge to approach (move towards) in response to each picture on a scale from 1 (*low*) to 9 (*high*) with no neutral point labelled (Figure1c). This was a new scale created for this study, which was intended to operationalise the approach motivation of various picture stimuli. A 9-point scale was used to be consistent with the valence and arousal scales[2].

Avoidance motivation ratings. Thirty participants (18 female, 11 male, 1 other; M_{age} = 19.03, SD_{age} = .89, age range: 18-21) rated pictures based on how strong they felt their urge to

[2] In Study 1a, we did not want to make assumptions about the structure of motivational intensity. Therefore, we used a dual-structure of approach motivation and avoidance motivation, so that we could observe the relationship between these two scales. We found a very strong inverse correlation (r_s = -.89) between the approach motivation and avoidance motivation scales, indicating that motivational intensity should be measured on one bi-directional scale (ranging from avoid-approach). This led to the development of the bi-directional scale, which ranged from -4 (avoid) to +4 (approach) in Study 1b.

avoid (move away from) in response to each picture on a scale from 1 (*low*) to 9 (*high*) with no neutral point labelled (Figure 1d). For the same aforementioned reasons, this was a new scale produced for this study to operationalise the avoidance motivation of the picture stimuli.

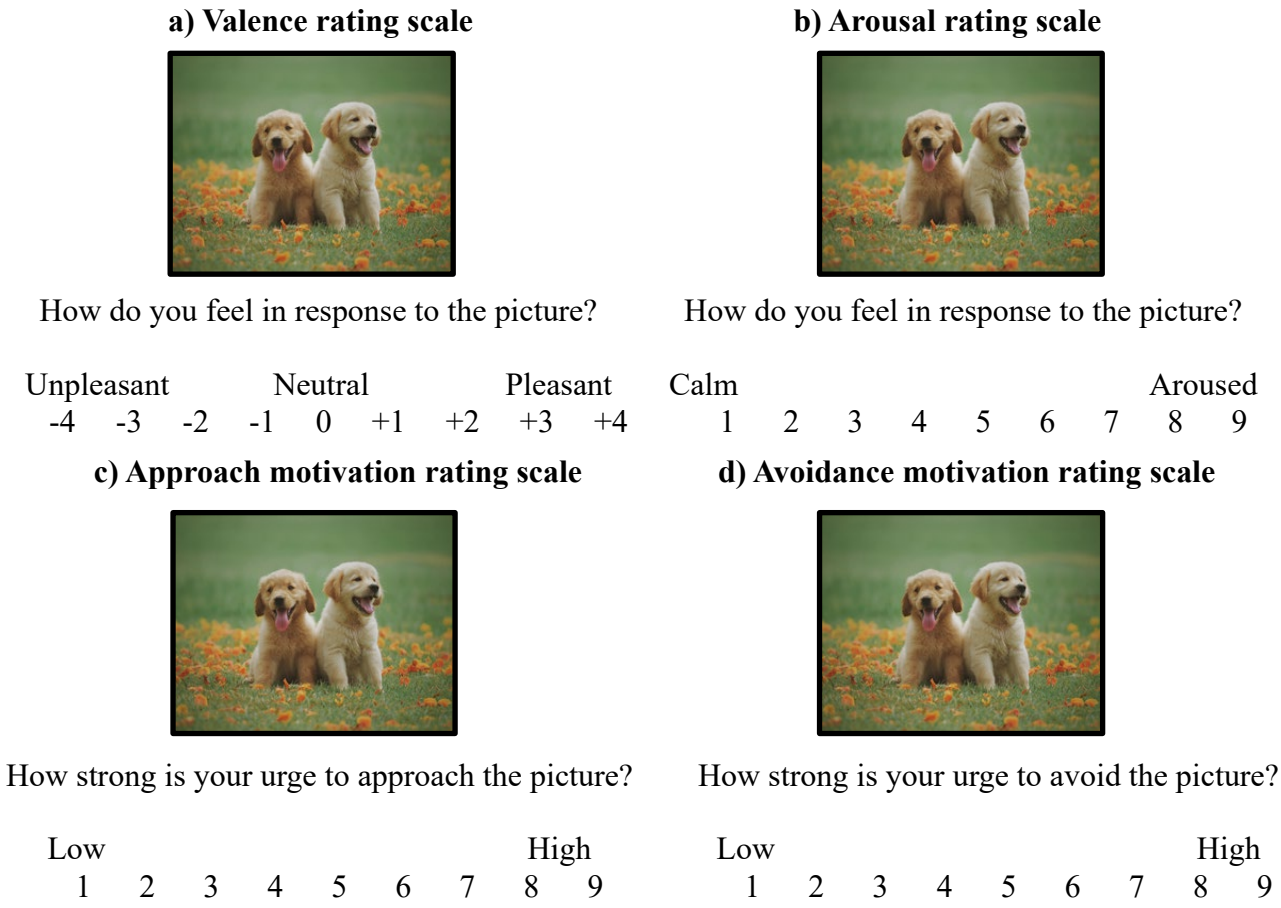


Figure 1. Example of stimulus and rating scales used in Study 1a. (a) Valence rating scale with a neutral point (0) included. (b) Arousal rating scale (neutral point not included). (c) Approach motivation rating scale (neutral point not included). (d) Avoidance motivation rating scale (neutral point not included). The example stimulus shown here is not an actual IAPS picture due to constraints around publications as not to compromise its success as a research tool, but this picture embodies a type of picture used in the IAPS.

Design and procedure. The study took approximately 1 hour to complete, and participants were compensated with course credit for their time. Prior to participation, in addition to general information about the experiment, participants were given explicit warning about the nature of the emotionally-evocative pictures (e.g., erotica, mutilated bodies, attacks,

violence, and frightening animals) that were to be presented. They were told that they were able to withdraw from participation at any time if they felt uncomfortable. Participants then provided voluntary informed consent via a response to an explicit question about consent. If they answered no to this question, they did not continue beyond this point and were not included in the study.

Next, participants completed the background and demographics questionnaire detailed above. Participants were allocated to one of the four dimensions (valence, arousal, approach motivation, and avoidance motivation) based on which version of the study they selected on the research participation recruitment site (i.e., SONA). Note that the different versions made no reference to the dimension they would be rating, and instead were all simply equivalent variants of a generic picture rating study (e.g., "Online Image Rating Study" versus "Online Photo Rating Study"). Participants were unaware of the condition that they were allocated to because this was not outlined on the recruitment platform.

Participants were given clear instruction that they would be rating pictures based on 'how each picture made them feel at the time of viewing'. Onscreen instructions were provided on how to use the rating scale for each dimension. For the valence dimension, extra instructions were given to provide explanation on how to use the neutral point on the scale (see Appendix B for the specific instructions of each dimension and the definitions of each construct).

Participants first completed 12 practice viewing and ratings of pictures from the Internet that represented the six different categories used. Although there are no correct or incorrect answer for ratings, this helped to familiarise them with the task and the rating scale. After completion of the practice block, participants were informed that the next stage was the main block. The main block consisted of 300 pictures and rating scales, each presented together on the screen until response. If participants did not respond before continuing, a response was requested, but not required, before continuing. The order of the picture and rating scale

presentation was randomised for each participant. After completion of the experimental block, participants were presented with the debrief questions. Finally, participants were presented with 20 mildly positive royalty free pictures from the Internet. This was designed to mitigate any negative emotional impact resulting from the emotionally-evocative pictures.

Data screening. Overall, there was 0.04% missing individual scores across all remaining 120 participants, which were omitted from the average for each of their relative pictures. Participants' individual scores across all pictures were assessed for outliers. The criterion for determining and removing outliers was individual participants' ratings for a given picture where the z-scores values exceeded the absolute value of 3.29 relative to how all of the other participants rated that particular picture. This was assessed for all 300 pictures across all participants' scores (Tabachnick & Fidell, 2013). A total of two whole cases (i.e., all of an individual's data) were removed for being outliers on more than 15 (5%) pictures. An average of 0.24% individual outlier scores were removed across all remaining 120 participants. The four dimensions were assessed for normality. For some variables the distributions were not normal, suffering from significant skew or kurtosis (skew or kurtosis z-scores > 3.29), therefore, non-parametric Spearman's correlational analyses was used. Note that the results were similar when parametric correlations were used, see Supplementary Information.

Results and Discussion

Means and standard deviations for each picture on each dimension in this study, as well as a description and number of each picture is presented in the Supplementary Information, Table S1. The raw data will be placed into a pubic repository (OSF) upon manuscript acceptance. Please see Table S3 in the Supplementary Information for the Pearson's *r* correlations for each of the analyses discussed below.

Reliability. Each of the rating scales had high levels of internal consistency, as indicated by Cronbach's α. The valence, arousal, approach motivation, and avoidance

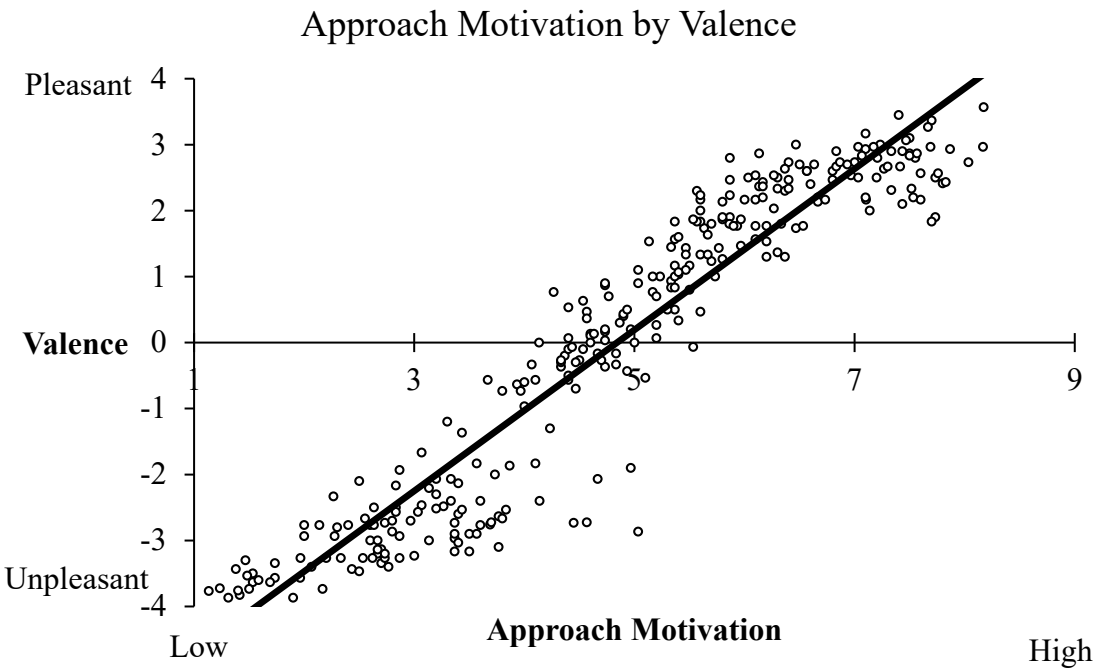
motivation ratings scales all had excellent internal consistency (Cronbach's α = .99, .96, .96, .98). Moreover, the maximum correlation that can be observed between two variables is constrained by the measurement reliability of both variables. This is quantified in Spearman's attenuation-correction formula (i.e., $r_{\text{true}} = \frac{r_{\text{observed}}}{\sqrt{r_{xx} \times r_{yy}}}$) (Parsons, Kruijt, & Fox, 2019; Spearman, 1904). Therefore, we reported the r_{true} for each of the primary analyses in this and all subsequent studies.

Validation check. For the 250 IAPS pictures, the relationship between the original ratings of valence and arousal collected using the SAM (Lang et al., 2008) and the ratings of these constructs from the present study was assessed via correlational analyses. The logic here was that if our methodology was functioning as expected, we should see strong associations between how our participants and the participants in the original IAPS study rated these pictures on valence and arousal. As expected, we observed strong and significant positive correlations between SAM valence ratings and our valence ratings, $r_s(248) = .95$, $p < .001$, [95% CI = .94 to .96] and between SAM arousal ratings and our arousal ratings, $r_s(248) = .82$, $p < .001$ [95% CI = .78 to .86]. This was despite us using a different rating scale, different participants, and collecting data several decades after original SAM ratings were collected.

The structure of motivational intensity. The structure of motivational intensity was examined by assessing the association of the scores from the present study approach motivation and avoidance motivation. A Spearman's r_s correlation indicated that there was a very strong negative correlation between approach motivation scores and avoidance motivation scores, $r_s(298) = -.89$, $p < .001$ [95% CI = -.91 to -.86]. This strong inverse correlation means that pictures that received high approach ratings received correspondingly low avoidance ratings. While it cannot be ruled out for all pictures, there is clear evidence against the notion that approach motivation and avoidance motivation are systematically independent dimensions. Instead, it supports the notion of a single dimension of motivational intensity.

Motivational intensity and valence. To explore the relationship between motivational intensity and valence, the correlation between both approach motivation and avoidance motivation on the one hand and valence on the other were considered. Approach motivation scores and valence scores were very strongly correlated, $r_s(298) = .96$, $p < .001$, [95% CI = .95 to .97], indicating an extremely high degree of correspondence between these two constructs (Figure 2a). That is, the pictures that were rated high on approach motivation were overwhelmingly likely to also be rated by other participants as high on valence. The estimated r_{true} for approach motivation and valence is $r_{\text{true}} = \frac{.96}{\sqrt{.96 \times .99}} = .98$, which supports the high degree of correspondence between these two constructs. Moreover, avoidance motivation and valence were negatively correlated, $r_s(298) = -.91$, $p < .001$, [95% CI = -.93 to -.89] indicating that avoidance motivation and negative valence also share a very high degree of overlap (Figure 2b). The estimated r_{true} of avoidance motivation and valence is $r_{\text{true}} = \frac{-.91}{\sqrt{.98 \times .99}} = -.92$, which supports the high degree of correspondence between these two constructs.

a)



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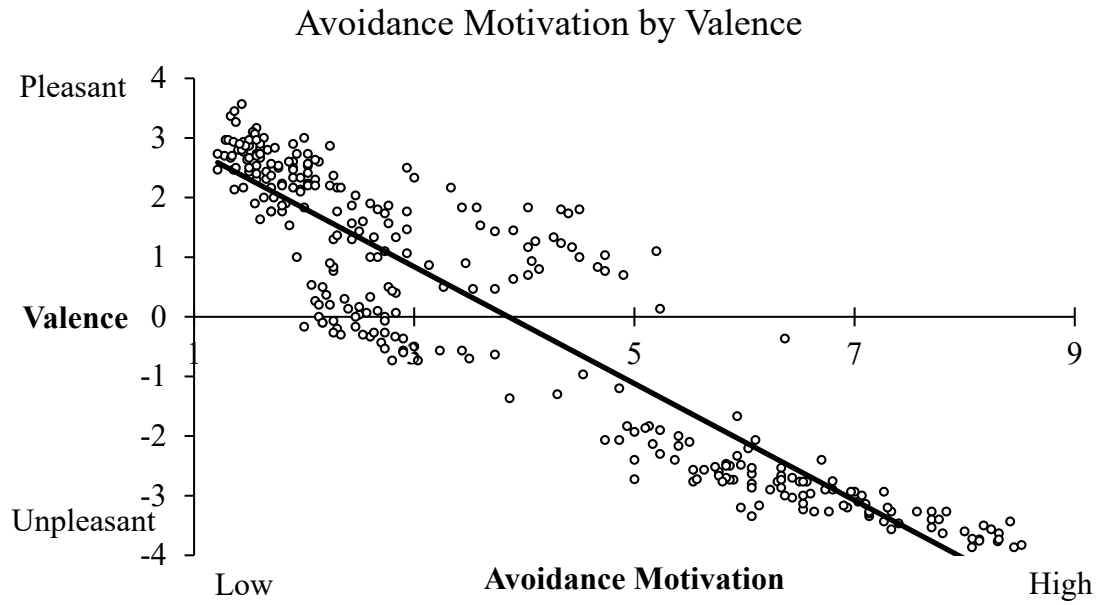
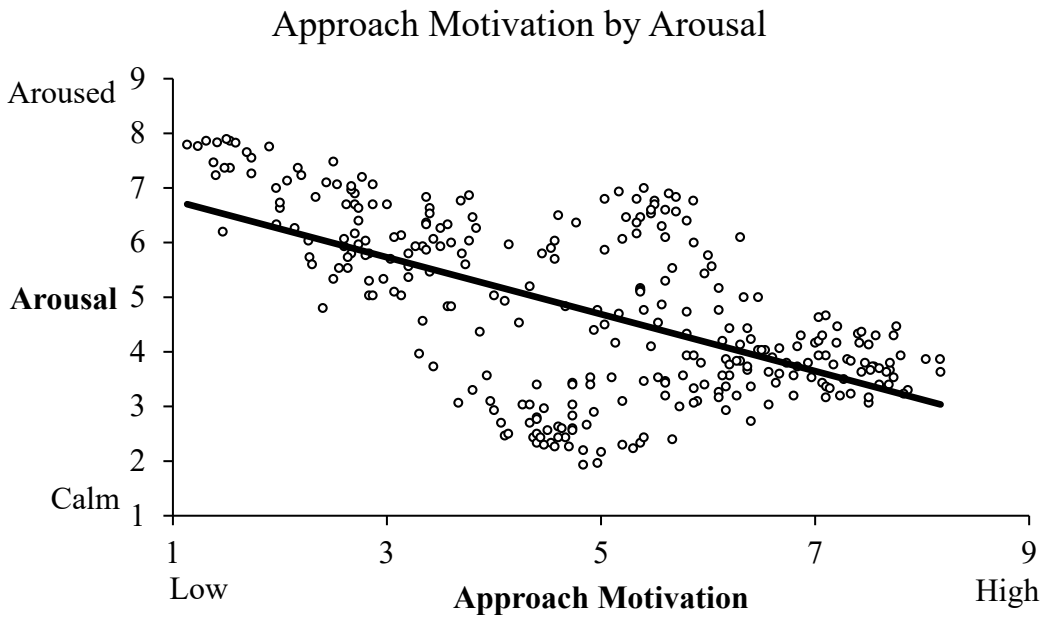


Figure 2. Scatterplots of (a) approach motivation by valence (r_s = .96) and (b) avoidance motivation by valence (r_s = -.91). Each dot represents the mean rating for a given picture on that rating scale. Black line indicates line of best fit. Approach motivation range: 1 (*low*) to 9 (*high*). Avoidance motivation range: 1 (*low*) to 9 (*high*). Valence range: -4 (*unpleasant*); +4 (*pleasant*); 0 (*neutral*).

Motivational intensity and arousal. To examine the relationship between motivational intensity and arousal, the scores of both approach motivation and avoidance motivation were correlated separately with arousal. Approach motivation scores and arousal scores were moderately inversely correlated, $r_s(298) = -.52$, $p < .001$ [95% CI = -.60 to -.43]. The r_{true} for approach motivation and arousal is $r_{\text{true}} = \frac{-.52}{\sqrt{.96 \times .96}} = -.54$. This indicates a degree of a relationship, albeit in the opposite direction to that predicted by the recommendation that increasing arousal serves as a proxy for increasing motivational intensity (Figure 3a). Moreover, avoidance motivation scores and arousal scores were positively correlated, $r_s(298) = .76$, $p < .001$, [95% CI = .71 to .80], and the $r_{\text{true}} = \frac{.76}{\sqrt{.98 \times .96}} = .79$, suggesting that avoidance motivation and arousal are related, yet distinct. That is, while they share variance, there is also substantive unshared variance as well (Figure 3b).

a)



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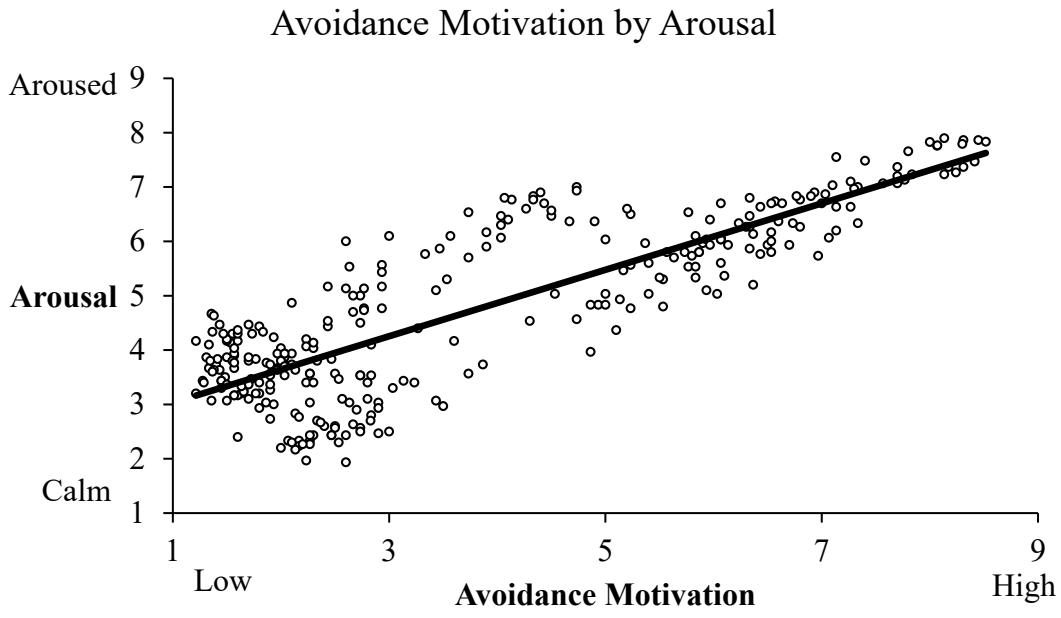
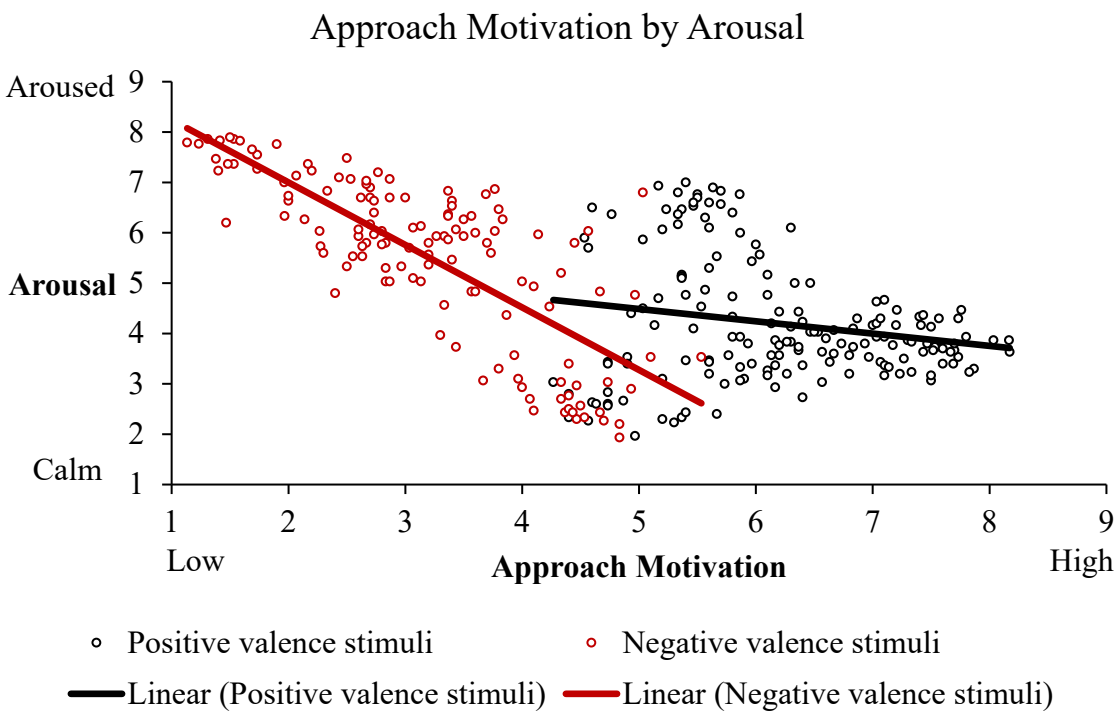


Figure 3. Scatterplots of (a) approach motivation by arousal (r_s = -.52) and (b) avoidance motivation by arousal (r_s = .76). Each dot represents the mean rating (averaged across participants) for a particular picture on that scale. Line indicates line of best fit. Approach motivation 1 (*low*); 9 (*high*). Avoidance motivation range: 1 (*low*); 9 (*high*). Arousal range: 1 (*calm*); 9 (*aroused*).

The previous analyses showed a high degree of correspondence between motivational intensity and valence, indicating substantial overlap between the two constructs. Moreover, an issue with the dual-structure of approach motivation and avoidance motivation is that both of these scales captured the full range of picture stimuli. It is possible that the approach motivation and avoidance motivation rating scales were treated by participants as bi-directional approach-avoidance scales rather than ranging from low to high on approach motivation and avoidance motivation. Therefore, it is important to examine positive (> 0) and negative (< 0) valence stimuli separately across the approach motivation and avoidance motivation rating scales. There was no reliable relationship for approach motivation and arousal for positive valence stimuli, $r_s(165) = -.11$, $p = .179$, [95% CI = -.26 to .04]. Moreover, approach motivation and arousal were inversely correlated for negative valence stimuli, $r_s(128) = -.79$, $p < .001$, [95% CI = -.85 to -.72]. This indicates there is a relationship for only negative valence stimuli between approach motivation and arousal (Figure 4a). There was a moderate correlation between avoidance motivation and arousal for positive valence stimuli, $r_s(165) = .50$, $p < .001$, [95% CI = .38 to .61], and a very strong correlation between avoidance motivation and arousal for negative valence stimuli, $r_s(128) = .95$, $p < .001$, [95% CI = .93 to .96] (Figure 4b), suggesting that avoidance motivation and arousal are related. Overall, there was an inconsistent relationship between motivational intensity and arousal, which indicates that arousal may not be an appropriate proxy for motivational intensity.

a)



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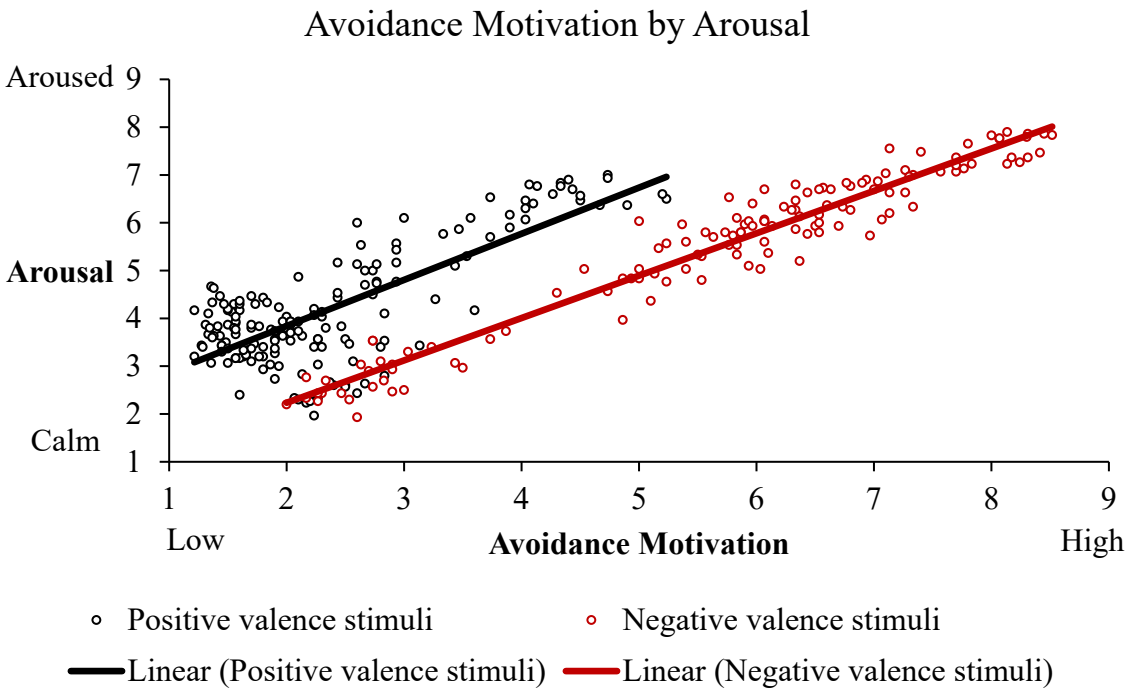

Figure 4. (a) Approach motivation and arousal plotted separately for positive valence stimuli (r_s = -.11) and negative valence stimuli (r_s = -.79). (b) Avoidance motivation and arousal plotted separately for positive valence stimuli (r_s = .50) and negative valence stimuli (r_s = .95). Each

dot represents the mean rating (averaged participant response) for each picture on that rating scale. Black line indicates line of best fit for positive valence stimuli. Red line indicates line of best fit for negative valence stimuli. Approach motivation range: 1 (*low*); 9 (*high*). Avoidance motivation range: 1 (*low*); 9 (*high*). Arousal range: 1 (*calm*); 9 (*aroused*).

Summary. Here, motivational intensity and valence showed a very strong relationship with one another. In fact, the relationships were so high, that one might even question whether motivational intensity is in fact a distinct construct from valence. In contrast, the relationships between motivational intensity and arousal were weaker and less consistent. However, in Study 1a we used two separate rating scales for the approach and avoidance aspects of motivational intensity, which meant that both of these separate rating scales captured the full range of picture stimuli. Given that approach motivation and avoidance motivation were very highly negatively correlated, this suggests that it may be more appropriate to measure motivational intensity on a single rating scale. This is what we did in Study 1b. This would allow us to assess whether the same relationships between approach motivation and avoidance motivation and arousal held when motivational intensity was rated on a single rating scale.

Study 1b: Combined Measurement of Approach Motivation and Avoidance Motivation on a Singular Dimension

In Study 1b, we sought to assess the robustness of results of the previous study by operationalising motivational intensity as a single dimension. Specifically, we replaced the separate approach and avoidance scales with a bidirectional scale that measured motivational intensity from avoid to approach via a neutral mid-point, and these responses were compared with the valence and arousal ratings from Study 1a.

Method

Participants. Participants were 30 undergraduate students aged 18 to 23 years (M_{age} = 20.1, SD_{age} = 1.4; 22 female, 8 male) recruited from the ANU community via an online system

for course credit[3]. Recruitment and exclusion criteria were as for Study 1a. In Study 1b, participants rated how much effort they put into their responses, ranging from 1 (*no effort*) to 10 (*maximum effort*), the average response was 8.37 (*SD* = 1.16, range: 6.00-10.00). 70% of participants responded that they generally eat desserts, 93.3% of participants indicated that they generally enjoy desserts, and 70% of participants had eaten within 2 hours prior to completing the questionnaire. Please see Table S4 and S5 in the Supplementary Information for analyses on how ratings changed as a product of eating-behaviour.

Stimuli and procedure. The stimuli and procedure were identical to those used in Study 1a. This time however, participants rated how much they felt an urge to avoid (move away from) or approach (move towards) in response to each picture, on a scale from -4 (*avoid*) to +4 (*approach*), with 0 labelled as the neutral point (Figure 5).

Figure 5. Example of the stimulus and rating scale used in Study 1b. Motivational intensity rating scale with a neutral point (0) included. 9-point rating scale ranging from -4 (*avoid*) to +4 (*approach*). The example stimulus shown here is not an actual IAPS picture due to constraints around publications as not to compromise its success as a research tool, but this picture embodies a type of picture used in the IAPS.

[3] The difference in sample sizes across Study 1a and 1b was due to the between-subjects design used in the current study. In total, there were 120 participants in Study 1a because each of the four dimensions employed 30 participants (30 x 4 = 120). Study 1b had a sample size of 30 because there was only one dimension being tested. Thus, Study 1a and 1b were consistent in that 30 participants were used per dimension.

Results and Discussion

Means and standard deviations of the ratings for each picture on each dimension as well as a short description of the picture is presented in the Supplementary Information, Table S1. Participants' scores were assessed for outliers across all pictures. The criterion for determining and removing outliers was ratings where there z-scores values exceeded the absolute value of $z = 3.29$ on any of the 300 pictures (Tabachnick & Fidell, 2013). One whole case was excluded from final analyses for being an outlier on more than 5% of pictures. An average of 0.41% individual outlier scores were removed across all 30 participants. There was an average of 0.05% missing individual scores across all remaining 30 participants, which were omitted from the averages of their respective pictures. The distributions were not normal for all variables, therefore Spearman's rho was used. Please see Table S3 in the Supplementary Information for the Pearson's *r* correlations for each of the analyses discussed below. Further, the new motivational intensity rating scale had excellent internal consistency (Cronbach's $\alpha = .97$).

The ratings on this new dimension were compared with the valence and arousal ratings of the same pictures from Study 1a. There was a very strong correlation between motivational intensity and valence scores, $r_s(298) = .96$, $p < .001$, [95% CI = .95 to .97], with the $r_{\text{true}} = \frac{.96}{\sqrt{.97 \times .99}} = .98$, indicating an exceptionally high degree of overlap between these two dimensions (see Figure 6). This supports findings from Study 1a that motivational intensity and valence are very closely related, such that it challenges the notion that motivational intensity exists independent of valence.

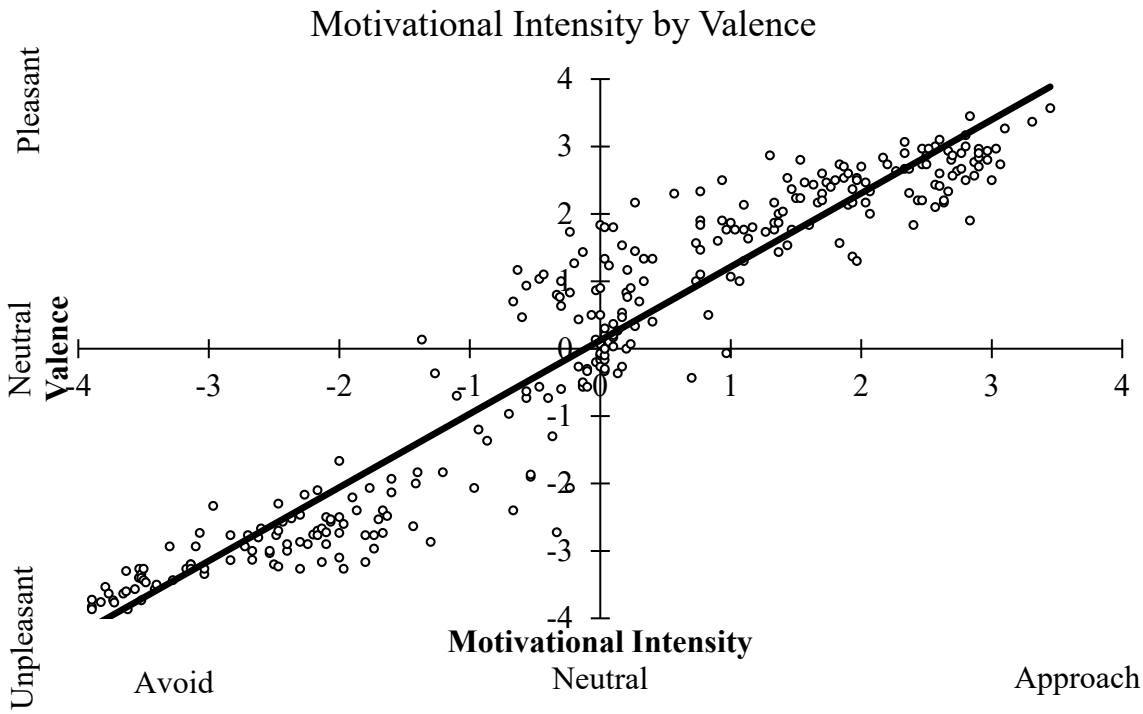

Figure 6. Scatterplot of motivational intensity (Study 1b) by valence (Study 1a) (r_s = .96). Each dot reflects the mean rating of a particular picture. Line indicates line of best fit. Motivational intensity range: -4 (*avoid*) to +4 (*approach*), with 0 as neutral; Valence range: -4 (*unpleasant*) to +4 (*pleasant*), with 0 as neutral.

The relationship between the single dimension of motivational intensity and arousal was also examined. The single dimension motivational intensity absolute scores (i.e., considering the magnitude of the scores ignoring their sign) were assessed against arousal scores to answer the question regarding whether arousal is an appropriate proxy for motivational intensity. Considering absolute value is necessary because unlike valence which is essentially bipolar (negative to positive), arousal is conceptualised and measured on a single dimension from low to high arousal. Therefore, taking the absolute value of the motivational intensity score renders it on a comparable scale to arousal. Eight pictures were excluded from the following analyses because they received true motivational intensity ratings of 0 averaged across all participants. Here, a moderate correlation was observed between motivational intensity and arousal scores, $r_s(290) = .41$, $p < .001$, [95% CI = .31 to .50], with the $r_{\text{true}} =$

$\frac{.41}{\sqrt{.97 \times .96}}$ = .42, indicating that there is a moderate relationship between motivational intensity and arousal when the absolute scores of avoidance motivation and approach motivation are considered together (see Figure 7). To explore this question further, the data was split by approach motivation and avoidance motivation so that the relationship between both of these motivational directions could be assessed with arousal separately. There was a significant correlation between the ratings of the pictures for avoidance motivation and arousal, $r_s(135)$ = .69, $p < .001$, [95% CI = .59 to .77], with the $r_{\text{true}} = \frac{.69}{\sqrt{.97 \times .96}}$ = .72, indicating that avoidance motivation and arousal are related. However, there was no reliable correlation observed between approach motivation and arousal rating scores, $r_s(153)$ = .10, p = .204, [95% CI = -.06 to .25], with the $r_{\text{true}} = \frac{.10}{\sqrt{.97 \times .96}}$ = .10, indicating that there is not a meaningful relationship between approach motivation and arousal. Although a relatively strong relationship was observed between avoidance motivation and arousal, overall, arousal is not an appropriate proxy for motivational intensity because there was no relationship observed between approach motivation and arousal.

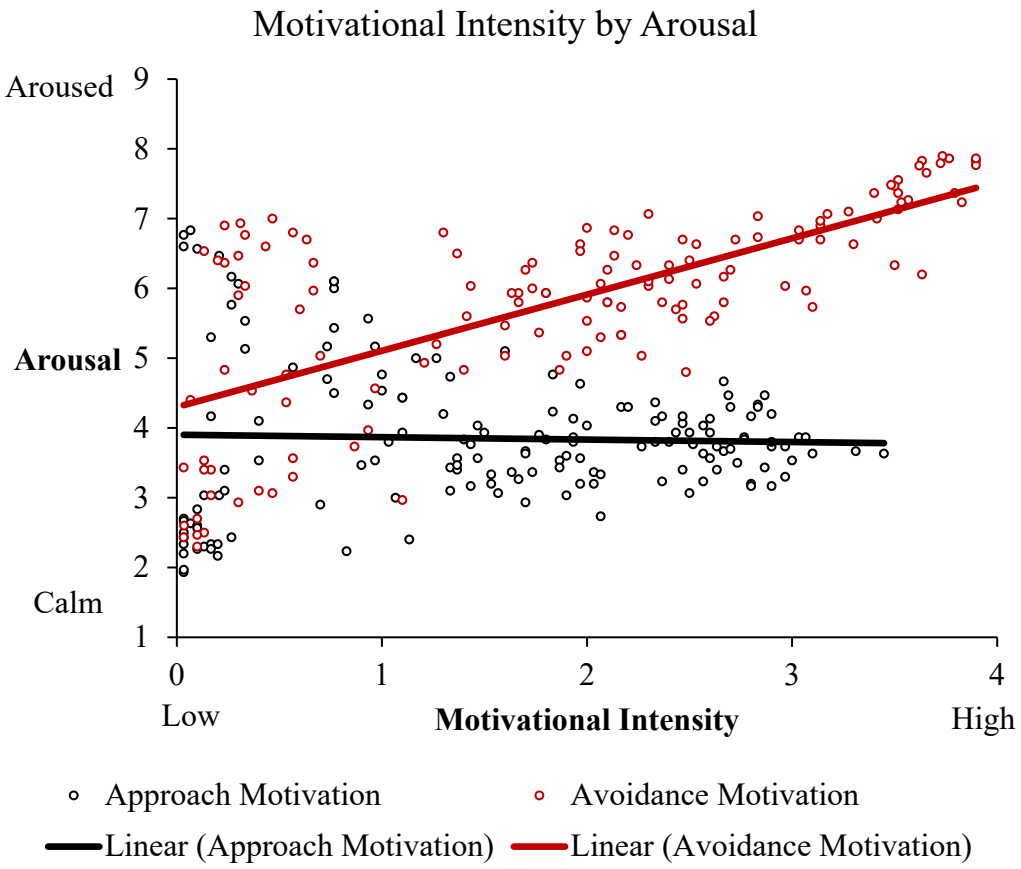

Figure 7. Scatterplot of motivational intensity (Study 1b) against arousal (Study 1a) (r_s = .41), separated by approach motivation (r_s = .10) and avoidance motivation (r_s = .69). The absolute score of approach motivation and avoidance motivation has been used in this analysis. Each dot represents the mean rating score for a given picture. Black line indicates line of best fit for approach motivation, red line indicates line of best fit for avoidance motivation. Motivational intensity range: 0 (*low*); 4 (*high*). Arousal range: 1 (*calm*); 9 (*aroused*).

Summary

The results from Study 1b replicated the findings from 1a, where we found an overwhelming correspondence between motivational intensity and valence. This supports the notion that motivational intensity is not a distinct construct, and instead appears to be another label for the existing and well-established dimension of valence. However, Studies 1a and 1b relied on self-report measures. We do not think this is intrinsically problematic, as the validity of a measure (i.e., does it selectively and sensitively gauge the construct of interest?) is more

important than whether it is explicit or implicit. Indeed, emotions include subjectively experienced aspects, which we expect participants are able to report with a reasonable degree of accuracy. However, in Study 2, we sought converging evidence for our conclusion on an implicit measure.

Our design was derived from one key piece of information: reaction times (RTs) gauge decisional uncertainty (e.g., Kiani, Corthell, & Shadlen, 2014). When participants make a classification judgement RTs are slower when this decision is ambiguous or otherwise difficult than when it is clear-cut and easy. This means that if participants are classifying the valence of their emotional response, they should be faster to make this decision for pictures that elicit more extreme positive or negative reactions, and slower for neutral pictures. The same logic applies for motivational intensity, for pictures that are easy to classify (i.e., strong urge to approach or avoid), RTs will be faster, and for pictures that are less easy to classify (i.e., pictures classified as neutral) RTs will be slower. Therefore, RT is used as an implicit measure to classify the valence and motivational intensity of the picture-evoked emotion.

Crucially, if motivational intensity and valence are overwhelming related and different labels for the construct as we have argued, there should be a high correlation between the valence and the motivational intensity-based RTs to each picture. The same pictures that produce quick RTs when participants are classifying the pictures according to valence should also facilitate quick RTs when participants are classifying the pictures according to the motivational intensity. Similarly, the same pictures that produce slow RTs on valence should produce slow RTs on motivational intensity.

Study 2: Behavioural Measure of Motivational Intensity and Valence

Method

Participants. Thirty participants (26 female) aged between 19 and 38 (M_{age} = 25, SD_{age} = 3.45) were recruited by word of mouth or through ANU's online recruitment platform

(SONA) and either volunteered their time or were offered compensation in 1 course credit for eligible courses (when participation was completed in conjunction with course-specific requirements). One participant was excluded and replaced due to not being born in a Western country. All participants included in final analyses met the recruitment criteria as detailed in Study 1a and 1b.

Stimuli. The study was conducted online via Testable (www.testable.org). In ascending order, every 3rd ranked picture (100 pictures total) were selected from the motivational intensity ratings collected in Study 1b (see Appendix C for a list of the pictures used). This was done to ensure that a diverse range of pictures that represented the motivational intensity scale were selected.

Black borders were removed from IAPS pictures, and each landscape and portrait picture were resized to 600px wide and 600px high, respectively. For each trial, pictures were presented in the centre of participants screens. Pictures were presented on a white background.

Procedure. A within-subjects design was employed for this study, with the dependent variable RT. The study took approximately 45 minutes to complete. There were two blocks involved in this experiment (Motivational Intensity and Valence). Once participants had completed the two blocks the first time (Motivational Intensity$_{block\text{-}1}$ and Valence$_{block\text{-}1}$), they then repeated the two blocks again (Motivational Intensity$_{block\text{-}2}$ and Valence$_{block\text{-}2}$). The repetition of the blocks was included to examine the internal consistency and reliability of the Motivational Intensity and Valence measures. Order presentation of the blocks was counterbalanced among participants, however, it was ensured that Motivational Intensity$_{block\text{-}1}$ and Valence$_{block\text{-}1}$ came before Motivational Intensity$_{block\text{-}2}$ and Valence$_{block\text{-}2}$.

In Motivational Intensity$_{block\text{-}1}$ and Valence$_{block\text{-}1}$ participants completed 10 practice trials (prior to the experimental trials) on pictures that were not included in the experimental blocks. Within each of the experimental blocks (Motivational Intensity or Valence) participants

made responses to the same 100 picture stimuli from Study 1b. Order presentation of the pictures were randomised in each block. Following completion of the experimental blocks, all participants viewed but did not make responses to 20 pictures sourced from the Internet for 3 s, which was designed to mitigate the effect of the negative images on participants.

On each trial, for both of the Motivational Intensity and Valence blocks, after a period of fixation (500 ms), the picture stimulus was shown until participants made a response. In the valence blocks, participants' task was to classify their emotional response to the picture using the arrow keys on their keyboard (left key for unpleasant; right key for pleasant). For the motivational intensity blocks, participants were instructed to classify if they felt an urge to avoid the picture using the arrow keys on their keyboard (left key for avoid; right key for approach). Participants were instructed to respond as quickly and accurately as possible. After participants made their response, another central fixation cross appeared (500 ms), which represented the inter-trial interval (see Figure 8 for an example of a single trial in Study 2).

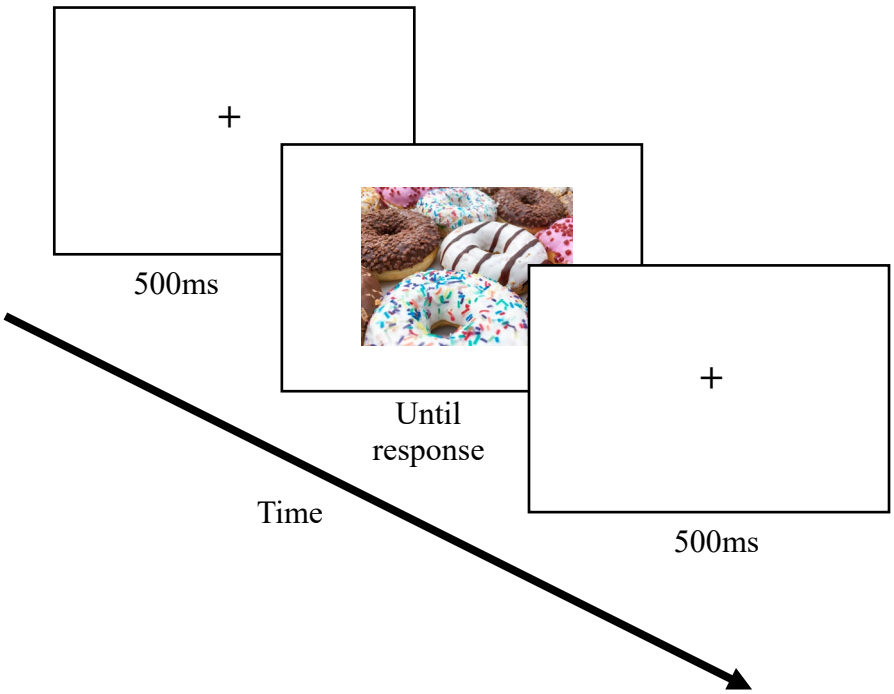

Figure 8. Schematic illustration of a single trial used in Study 2. One-hundred picture stimuli were selected from Study 1b ratings. Picture presentation was randomized within each block. Response was either avoid or approach (Motivational Intensity blocks), or unpleasant or pleasant (Valence blocks). Order of block presentation is counterbalanced among participants.

Results and Discussion

In the following sections, we first calculated the reliability of measures to provide an estimate of the expected upper bound (r_{true}) of possible observed relationships motivational intensity and valence. Given that RT measures typically have imperfect reliability, we calculated a r_{true} value when assessing the relationship between valence and motivational intensity.

We then assessed the evidence for our assumption that RTs would change as a function of the extremeness of the motivational intensity rating that the picture received in Study 1b. Finally, we calculated the correlation between our implicit measures of valence and motivational intensity to assess the key research question.

Table 1 reports the means, SDs and Cronbach's α for each measure, by block and combined. The first and second blocks within each task were strongly correlated (motivational intensity: $r(98) = .72$, $p < .001$, [95% CI = .61 to .80]; valence: $r_s(98) = .71$, $p < .001$, [95% CI = .60 to .80][4]) and combining the two blocks increased internal consistency relative to each of the individual blocks. Thus, we collapsed across the two blocks within each task in all subsequent analysis. Please see Appendix D in the Supplementary Information for test-retest reliability.

Figure 9 illustrates the relationship between ratings of motivational intensity from Study 1b and mean reaction times in the motivational intensity decision and valence decision tasks in Study 2 (Supplementary Table S2 also presents data for each stimulus). As expected, reaction times were slower for pictures around the midpoint of the motivational intensity rating scale, and faster for pictures at the extreme ends of the scale, forming a V-shaped relationship. Given that the linear relationships were expected to go in different directions as a function of

[4]Here, we reported non-parametric Spearman's *r* because $Valence_1$ and $Valence_2$ were non-normal (i.e., skew and kurtosis scores >1.96). The Pearson's *r* for $Valence_1$ and $Valence_2$ was, $r(98) = .62$, $p < .001$. All other RT variables were normally distributed.

whether motivational intensity ratings were above or below zero (i.e., positive for avoid pictures and negative for approach pictures, forming the V-shape), we calculated correlations with motivational intensity and valence RTs separately for the pictures with motivational intensity ratings below and above zero. Three pictures were excluded from analyses because they received true 0 motivational intensity ratings averaged across all participants. Four correlations were calculated (shown in Figure 9) that support the V-shape pattern.

Table 1

Descriptive Statistics for Reaction Time (RT) Variables in Study 2 (*N* = 100)

RT Variable	*Mean* (ms)	*SD* (ms)	Cronbach's α
Motivational Intensity$_{1}$	1051	202	.69
Motivational Intensity$_{2}$	786.4	105	.57
Motivational Intensity$_{combined}$	919	143	.79
Valence$_{1}$	934	170	.79
Valence$_{2}$	759	103	.53
Valence$_{combined}$	847	123	.80

Note. Motivational Intensity$_{combined}$ is each motivational intensity picture rating averaged across Motivational Intensity$_{block-1}$ and Motivational Intensity$_{block-2}$. Valence$_{combined}$ is each valence picture rating averaged across Valence$_{block-1}$ and Valence$_{block-2}$. Sample size refers to number of pictures used in the analyses.

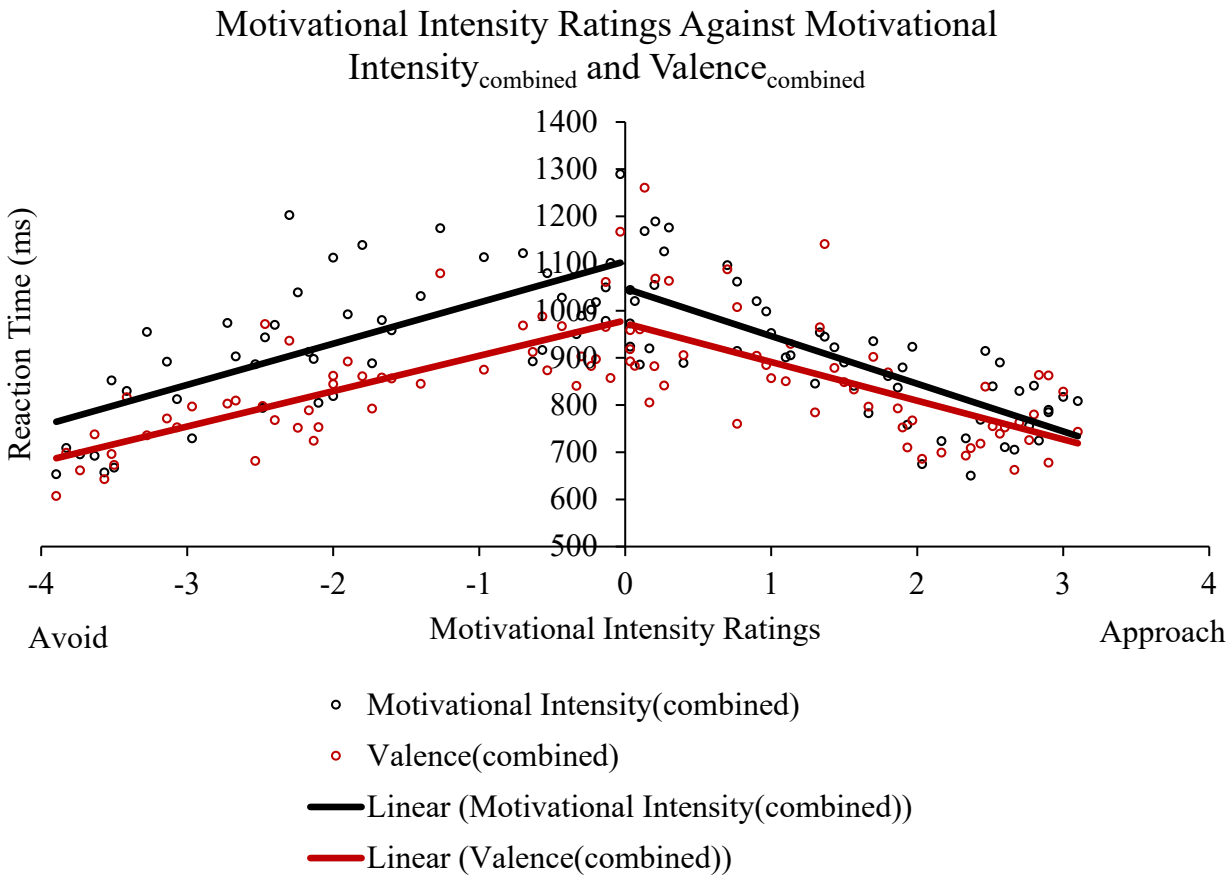

Figure 9. Scatterplot of avoidance motivation ratings (Study 1b) against Motivational Intensity$_{combined}$ (r(44) =.70, p <.001, [95% CI = 0.51 to 0.82], Study 2) and Valence$_{combined}$ (r(44) =.78, p <.001, [95% CI = 0.633 to 0.873], Study 2), and approach motivation ratings (Study 1b) against Motivational Intensity$_{combined}$ (r(49) = -.77, p <.001, [95% CI = -0.863 to -0.628], Study 2) and Valence$_{combined}$ (r(49) = -.65, p <.001, 95% CI = -0.785 to -0.456], Study 2). Black line indicates line of best fit for Motivational Intensity$_{combined}$. Red line indicates line of best fit for Valence$_{combined}$. Motivational Intensity$_{combined}$ is the average of Motivational Intensity$_1$ and Motivational Intensity$_2$. Valence$_{combined}$ is the average of Valence$_1$ and Valence$_2$. Motivational intensity rating range: -4 (*avoid*); 0 (*neutral*); +4 (*approach*).

We calculated the correlation between the mean RT for each picture (averaged across blocks and across participants). This revealed a strong correlation between Motivational Intensity$_{combined}$ and Valence$_{combined}$, r(98) = .77, p <.001, [95% CI = .68 to .84] (see Figure 10). Using the attenuation-correction formula to correct for the imperfect reliability of the

individual measures, the corrected estimated correlation is $r_{\text{true}} = \frac{.77}{\sqrt{.80 \times .79}} = .97$. This indicates that we found a high degree of correspondence between motivational intensity and valence for our implicit measure.

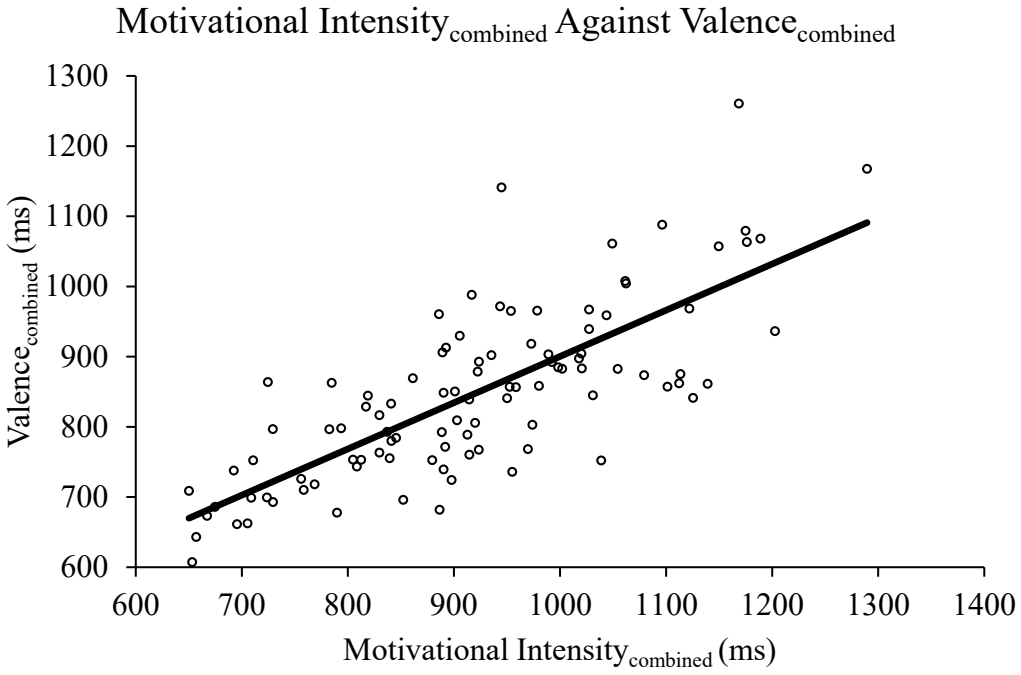

Figure 10. Scatterplot of Motivational Intensity$_{\text{combined}}$ against Valence$_{\text{combined}}$ ($r(98) = .77$, $p < .001$). Black line indicates line of best fit.

General Discussion

The present studies assessed the relationship between motivational intensity and the established dimensions for understanding emotion and its effect on cognition: valence and arousal. This served two purposes. First, it allowed us to assess the claim that the *arousal* associated with the emotion induced by a stimulus is an appropriate proxy for operationalising the motivational intensity of that emotion, and second, it allowed us to determine whether there is validating evidence that motivational intensity exists as a viable construct distinct from valence and arousal. To test this, we collected ratings of motivational intensity, valence, and arousal for a large and diverse range of picture stimuli, predominately selected from the widely used and validated (for valence and arousal) IAPS database, and then assessed the associations

between the different rating dimensions. We found a very high degree of association between motivational intensity and *valence*, and a more moderate relationship between motivational intensity and arousal. This high correspondence was true both when participants provided explicit ratings of valence and motivational intensity for the images, and also when we quantified valence and motivational intensity implicitly via RT in a classification task. Altogether, this calls into question the use of arousal as a proxy for motivational intensity, and indeed, more critically, challenges whether motivational intensity has sufficient merit as a construct to be considered distinct from valence at all. Motivational intensity may be valence by another name. This casts doubt on whether motivational intensity can make a useful unique theoretical contribution when it overlaps so fully with the well-established theoretical dimension of valence (Bradley & Lang, 2007a; Russell, 1980). These implications are discussed more fully in the following two sections.

Should Arousal be Used as a Proxy for Motivational Intensity?

Researchers have suggested that arousal is an appropriate proxy for motivational intensity, in that high arousal states correspond to high motivational intensity states, and low arousal states to low motivational intensity states (Gable & Harmon-Jones, 2008a, 2010c; Harmon-Jones, Gable, & Price, 2011). Previously the proponents of motivational intensity have claimed that arousal is a distinct construct from motivational intensity, stating that, "unlike arousal, motivation always has action implications (even if they are vague)" (Gable & Harmon-Jones, 2013, page. 345), and their rationale is based on a suggestion from Bradley and Lang's (2007a) work. However, the proponents used arousal as a proxy of motivational intensity, whereby they used IAPS ratings of arousal to represent levels of motivational intensity (e.g., low arousal = low motivational intensity, Gable & Harmon-Jones, 2010a).

The reliance on arousal ratings likely stems from the absence of systematic ratings of motivational intensity akin to those available for valence and arousal when the construct was

introduced into the literature. However, we argue that any claim about the purported relationship between arousal and motivational intensity is untenable in the absence of a comparison between systematic arousal and motivational intensity ratings to a large set of pictures, such as those that we provide here.

Our results indicated that motivational intensity and arousal have only a modest relationship. Moreover, although a relationship was shown between avoidance motivation and arousal, an inverse relationship (Study 1a) and no relationship (Study 1b) was observed between approach motivation and arousal. Overall, this indicates that arousal is not an appropriate proxy for motivational intensity, as the relationship would have to exist in both motivational directions for arousal to be considered an appropriate proxy for motivational intensity. This undermines the utility of arousal as a proxy for motivational intensity. Instead, the *valence* ratings of the feelings elicited by each picture had a much stronger and more consistent correspondence with the motivational intensity ratings that different individuals provided in response to that same picture. If anything, valence ought to be the proxy for motivational intensity. However, the overlap between motivational intensity and valence was so large and extensive, it calls into question whether motivational intensity should be considered distinct from valence at all.

Is Motivational Intensity Distinct from Valence?

Results demonstrated that motivational intensity and valence are *very* closely related. Indeed, in Study 1b, the correlation between participants' ratings of the motivational intensity evoked by the pictures and their valence ratings was approaching a perfect correlation ($r = .96$), and was on a par (indeed numerically higher) than the correlation between IAPS valence and the present study valence dimensions ($r = .95$) – a correlation between two different studies rating the *same* construct (valence). Similarly, in Study 1a, the absolute value of the correlations between the separate dimensions of motivational intensity and valence were in

excess of .9. This correspondence is striking in light of the fact that a different group of participants provided the motivational intensity versus valence ratings of the pictures. Furthermore, in Study 2, there was a strong correlation (r = .77), which was also extremely strong when corrected for the observed reliability of the RT measures (r = .97). This presents a serious challenge to the validity of motivational intensity as a construct distinct from valence It would appear that motivational intensity and valence are not distinct constructs. Instead, it may be that motivational intensity is a response to valence. Indeed, the intimate link between valence and motivational intensity, such that positive valence drives approach motivation and negative valence avoidance motivation is identified in early models of the architecture of emotion (Watson, 2000).

It should be kept in mind, however, that while this study collected ratings from a large set of pictures, a limitation is that the full gamut of human emotions is not captured. It is possible that a clearer divergence between motivational intensity and valence occurs for emotions not captured in these studies. For instance, it is difficult to evoke *anger* via IAPS pictures (Mikels et al., 2005), and this is one of the forms of emotional experience that has been suggested to differentiate valence from motivational intensity, such that it is a negative-valence but high in *approach* motivational intensity (e.g., Carver & Harmon-Jones, 2009; Gable et al., 2015). However, this divergence is a claim, and one that remains minimally tested, and when it is tested, the evidence contradicts this claim. For example, the ratings of motivational to approach or avoid in response to a single film that was designed to be anger-inducing do not support the claim that anger is associated with approach motivation (Gable et al., 2016; Gable et al., 2015) Indeed, in Gable et al. (2016), participants clearly indicated that anger was associated with avoidance, not approach motivation. This is critical, because the proponents of motivational intensity argue that anger is negative valence but approach motivated, and therefore any effects of anger on cognition or frontal cortical asymmetries as measured by EEG

need to be explained by the variable motivational intensity, rather than valence. We do not believe that there is sufficient evidence for this assertion given the limited ratings data available in the literature so far which appear to contradict this claim, and the current results suggest a very high degree of overlap between motivational intensity and valence. However, we did not specifically include anger manipulations here, and so it is theoretically possible that some categories of emotion such as anger could produce a divergence between valence and motivational intensity, and this awaits future research in which a large range of stimuli including those that evoke anger are rated with respect to valence and motivational intensity.

Implications

If motivational intensity is not truly distinct from valence, then this has significant implications for the field's understanding of how emotion and motivation impact cognition. It is possible that previous attempts to operationalise motivational intensity actually reflected different extremities of valence, in contrast with the focus of previous theories which were based on the direction of valence, and therefore, it was varying extremities of valence that were responsible for the observed effects on attentional and cognitive broadening/narrowing. For example, in one of the original papers that claimed to investigate motivational intensity (Gable & Harmon-Jones, 2010a), participants viewed pictures that were sad, disgusting, or neutral, and then completed a task designed to measure attentional breadth. Those who viewed the sad pictures were found to have broader attention when they viewed the sad pictures compared with the neutral pictures. However, those who viewed the disgusting pictures were found to have narrower attention when they viewed the disgusting pictures compared to when they viewed the neutral pictures. Gable and Harmon-Jones attributed this to the *disgusting* pictures having stronger motivational intensity than the *sad* pictures. However, the alleged relationship between disgust and sadness on the one hand and motivational intensity on the other was assumed, not validated. Instead, if extremity of valence mediates the relationship between

emotion and attention, the results could reflect the disgust pictures having more extreme negative valence than the sadness pictures. In support of this idea, the ratings obtained in that study indicated that the disgust pictures elicited more feelings of unpleasantness than did the sad pictures (Gable & Harmon-Jones, 2010a). In this light, it is interesting that in the early studies, there was never a direct comparison between different-valence stimuli (e.g., positive and negative together), only between same-valence stimuli (e.g., both negative, with what was thought to be different motivational intensities) (e.g., Gable & Harmon-Jones, 2008a, 2010a). It appears that the implicit assumption here is that all positive valence stimuli belong to a monolithic category of *positive* and all negative valence stimuli belong to a monolithic category of *negative*, which is not the case. Instead IAPS and other systematic rating studies have shown that there are degrees of positive valence, and two stimuli can both be positive in nature, but one relatively more positive than the other. Such gradations in valence have not always been accounted for in studies that have sought to test the effect of motivational intensity on cognitive or neuroscientific outcome variables, and so it is entirely possible that more extremely valenced stimuli (i.e., extreme positive and extreme negative) narrow attentional breadth whereas more intermediate valences (close to neutral) broaden it. This is an interesting possibility to be tested systematically in future research. Altogether, this demonstrates how the results attributed to motivational intensity might actually reflect valence. Of course, this remains speculation, and the actual driver of the emotion-cognition nexus awaits systematic testing in which the different dimensions are validly operationalised and directly pitted against one another. The present study highlights the need for such testing using systematically rated pictures rather than relying on assumptions – and the ratings we have collected here can be used for this purpose.

In summary, it has been claimed that motivational intensity is the driver of emotion-cognition effects, and it has also been suggested that arousal could be used as a proxy for motivational intensity when selecting stimuli for research. We present systematic evidence that

challenges both of these claims. First, we found that motivational intensity was much more closely aligned with valence than arousal. Second, the relationship between motivational intensity and valence was so strong, and the overlap so large, that it calls into question whether motivational intensity is indeed distinct from valence, or simply valence given another name. Motivational intensity is a theoretical construct that has had a substantial impact on theorising about how emotion affects cognition. If it is not truly a distinct construct, then all of the previous studies, behavioural and neuroscientific, which have claimed to reflect the influence of motivational intensity need to be reconsidered. In particular, it needs to be considered whether extremity of valence may instead be a better theoretical explanation for these observed results. Therefore, the present findings have potentially significant and far-reaching implications for understanding human emotion and cognition.

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