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General cognitive ability, as assessed by self-reported ACT scores, is associated with reduced emotional responding: Evidence from a Dynamic Affect Reactivity Task

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ABSTRACT

Dual process theories often contrast a hot, reactive affective system with a cool, reflective cognitive system. The cognitive system permits rationality and reasoning, but may inhibit spontaneous affect. Such frameworks would seem to suggest that individual differences in general cognitive ability, which is linked to abstract forms of reasoning, may impact dynamic components of emotional reactivity. In two studies involving five samples (total $N = 631$), participants were asked to continuously rate their emotional experiences in response to presented affective images. General cognitive ability, assessed, by proxy, with self-reported ACT scores, was linked to less intense peak reactions, peak reactions that were delayed, and/or to velocities of affect change that were less pronounced. Such relationships tended to be observed regardless of whether images were positive or negative. The findings provide support for dual process theorizing and suggest that general cognitive ability modulates dynamic components of emotional responding.

General cognitive ability, which captures skills related to reasoning, problem-solving, and abstract thinking (Gottfredson & Saklofske, 2009), has been shown to be a consequential predictor of performance-related outcomes at school (Brown, Wai, & Chabris, 2021) and in the workplace (Schmidt, 2002). However, the correlates of cognitive ability appear to be broader in nature, as they have been linked to outcomes in realms such as marital relations, criminality, social participation, and health and well-being (Brown et al., 2021; Gottfredson, 1998). Such individual differences, which can be assessed with a reasonable degree of precision through the use of scholastic achievement tests such as the SAT and ACT (Coyle, 2015; Frey, 2019), merit attention in ways that extend our analyses of how they operate. Block and Kremen (1996) have suggested that high ability individuals may be more comfortable with structured forms of thought than with their feelings and related analyses (e.g., Zabelina, Robinson, & Anicha, 2007) led us to focus on potential differences in "affective style" (Davidson, 1998) as a function of variations in general cognitive ability (GCA).

In this connection, it may be useful to link general cognitive ability to dual process theorizing (Carver, Johnson, & Joormann, 2009; Epstein, 2003; Evans, 2003; Strack & Deutsch, 2004). Evans (2003), for example, contrasts one system (System 1) that is evolutionarily old, affective, and intuitive with another system (System 2) that is particularly advanced among human beings and linked to abstract reasoning (also see Epstein, 2003). The latter system is thought to be constrained by working memory capacity and general intelligence (Evans, 2003). Within this framework, general cognitive ability might be conceptualized in terms of individual differences in System 2 operations and capacities. Other dual process theories add nuance to this analysis in suggesting that individuals with lower levels of general cognitive ability may typically react to events in a more reflexive (Strack & Deutsch, 2004) and affect-driven (Carver et al., 2009) manner. Such frameworks – and others (e.g., Rothbart, 2007) – suggest that it may be profitable, in understanding how individual differences in cognitive ability function, to examine emotional reactivity processes.

The dual process theorizing of Metcalfe and Mischel (1999) is particularly germane. In decomposing the delay of gratification paradigm, these authors contrast a hot, emotional "go" system (that seeks immediate gratification) with a cool, cognitive "know" system. The authors further suggest that the hot system represents a sort of default, such that the natural way of responding to appetitive or aversive events may be to react strongly to them. Such motivational processes would generally render it more likely that rewarding stimuli are approached,

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quickly and decisively, whereas threatening stimuli are avoided (Elliot, 2006; Lewin, 1935), a set of processes that is associated with deep organismic wisdom (Lang & Bradley, 2010; Panksepp, 2005). Some individuals, however, can down-regulate their tendencies toward reactivity through abstract thinking, such as by reconceptualizing a tasty food item in non-consummatory terms related to shape, color, or resemblance to objects that are not eaten (Metcalfe & Mischel, 1999). Mechanisms of this type are thought to support general cognitive ability (Mischel, Shoda, & Rodriguez, 1989). Hence, by this account, general cognitive ability may attenuate emotional reactivity.

In a series of papers, this analysis was extended by Ayduk and colleagues (e.g., Ayduk, Mischel, & Downey, 2002). According to these authors, emotion-eliciting events can be processed from one of two perspectives – a self-immersed perspective or a self-distanced perspective (Nigro & Neisser, 1983). The self-immersed perspective is a personal one in which events are experienced as happening to the self, causing a hot form of reactivity. This mode of processing is likely a default, especially when events are currently happening to us (Epstein, 2003). On the other hand, given cognitive capacities and a propensity toward abstraction, one could view the same events from a self-distanced or third-person perspective (Ayduk & Kross, 2010). When adopting this frame of reference, an observer self (akin to the "I" self: James, 1890) dissociates from the experiencing self (akin to the "me" self: James, 1890), essentially becoming a neutral observer of its own experiences. The self-distancing perspective is abstract and meta-cognitive in nature and would almost certainly be easier to achieve at higher levels of cognitive ability (Kross & Ayduk, 2017). This analysis is pertinent because Ayduk and Kross (2010) have shown that the self-distanced perspective, to the extent that one is able to achieve it, reduces emotional reactivity (also see Verduyn, Van Mechelen, Kross, Chezzi, & Van Bever, 2012).

In fact, a useful way of thinking about general cognitive ability may be to emphasize its meta-cognitive elements (Duncan et al., 2000). A person with lower levels of cognitive ability may react more simply and naturally to the emotional events that they are exposed to (Epstein, 2003) because the self is essentially immersed in its emotional environment (Ayduk & Kross, 2010). On the other hand, a person with higher levels of cognitive ability may, through mechanisms such as working memory capacity (Conway, Kane, & Engle, 2003), complicate their own emotional reactions. In addition to the reacting self, there would be an observing self and there would be thoughts about the reactivity process, essentially complicating it. This analysis comports with Borkovec's view of worry, which is conceptualized as meta-cognitive activity that serves an emotional avoidance function (Borkovec, Ray, & Stöber, 1998). This analysis also comports with suggestions that cognitively intelligent individuals may wish to distance themselves from their feelings (Block & Kremen, 1996) and they may be prone to overcontrol, which would inhibit spontaneity in one's affective reactions (Block, 2002; Zabelina et al., 2007).

To investigate these ideas, we examined potential relations between general cognitive ability, as assessed in an approximate manner by ACT scores (Koenig, Frey, & Detterman, 2008), and emotional processing. In order to investigate the posited differences in affective style (Davidson, 1998), we used a recently developed paradigm termed the Dynamic Affect Reactivity Task (DART: Klein, Jacobson, & Robinson, 2023) to probe for continuous affective responses to images selected because they have evoked strong forms of emotional reactivity in previous studies (Lang & Bradley, 2010; Lang, Bradley, & Cuthbert, 2005). Through the use of carefully developed algorithms, the DART is capable of identifying emotional onsets (i.e., the beginning of a subjective emotional response), peaks (i.e., the intensity of a reaction at peak intensity), and dynamic responding from onset to peak (Robinson, Klein, & Irvin, 2023). We were particularly interested in the velocity of affect change from onset to peak, which is thought to be the most dynamic component of reactivity (Robinson, Klein, & Irvin, 2023) and which can be linked to Davidson (1998) rise time to peak parameter, which may be particularly sensitive to temperament-related processes (Robinson, Klein, & Irvin, 2023). The key prediction was that individuals with higher levels of cognitive ability would display lesser velocities of affect change.

The use of both positive (appetitive) and negative (aversive) stimuli should offer insights into whether links between general cognitive ability and emotional reactivity can be ascribed to emotion regulation processes or to more general features of affective style (Davidson, 1998). Generally speaking, people are much more motivated to down-regulate their negative, relative to positive, emotional reactions (Kalokerinos, Résibois, Verduyn, & Kuppens, 2017). To the extent that general cognitive ability manifests itself in terms of emotion regulation processes, we should expect to find systematic interactions that are dependent on stimulus valence (appetitive versus aversive). If, on the other hand, links between cognitive ability and reactivity tendencies are more general in nature, they should be evident in terms of main effects that are not dependent on stimulus valence. We conducted two studies involving five samples of participants to examine these ideas.

1. Study 1

Four samples of participants completed the DART and reported on their ACT scores (Cole & Gonyea, 2010). This procedure allowed us to link variations in general cognitive ability, assessed in an approximate manner (Coyle, 2015; Frey, 2019), to variations in affective dynamics within a task that probed for momentary patterns of affect change. And it allowed us to directly replicate key findings – with minor procedural variations to support generalizability – given that such replications are scarce, but crucial to the development of a cumulative science (Simons, 2014). We report the results of four studies together for the sake of parsimony.

2. Method

2.1. Power-related considerations

Affective dynamics were examined using a within-subject design, which is a powerful one (Loersch & Payne, 2016). A power analysis, using G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007), indicated that 50 participants per sample would give us 0.8 power to detect medium-sized effects for stimulus valence, following precedent (Irvin, Klein, & Robinson, 2023). G*Power also indicated that 84 participants per sample would afford sufficient power (0.80) in detecting relationships involving an individual difference continuum in the 0.3 correlational range, also following precedent (Robinson, Irvin, & Klein, 2021). We aimed to exceed the 80 figure and therefore sought sample sizes in the range of 100 or above. Datasets for all studies are available at: https://osf.io/rjg9h/?view_only=66fab07128304a1b9600ee11c6bc8fa5 (Authors, 2022). We also uploaded a file named "Additional Measures" that lists measures not reported in the paper.

2.2. Participants and general procedures

All samples of participants were collected at a Midwestern University in the United States within a laboratory setting. Undergraduate students, who were seeking credit for their psychology classes (including introduction to psychology, which is a General Education course), signed up for a personality and emotion study using SONA registration software. They then showed up to the lab in groups of 6 or fewer and completed informed consent. Subsequently, participants were placed in private rooms, each with its own personal computer. The affect dynamic task was programmed with *E*-Prime software and ACT scores were collected, along with demographic information, using MediaLab software.

We sought replication across multiple datasets, which we believe strongly in (Simons, 2014), and therefore ran what should probably be regarded as slight variants of the same study (Brandt et al., 2014) four times. In Studies 1a-1d, 102 (71.57% female; 94.12% White; *M* age =

18.80), 151 (52.32% female; 90.73% White; *M* age = 18.92), 135 (45.93% female; 85.93% White; *M* age = 18.95), and 119 (68.91% female; 88.24% White; *M* age = 18.91) participants completed the affect dynamics protocol and also reported ACT scores. The small minority of participants who did not take the ACT test (about 5%, depending on study) were excluded from analyses.

2.3. General cognitive ability

Results from a number of studies have suggested that achievement-related tests like the SAT and ACT can be considered good proxies of general cognitive ability (GCA) or intelligence (Wai, Brown, & Chabris, 2018). Koenig et al. (2008) found that ACT test scores correlated with tests identified as intelligence tests as highly as those tests correlated with each other. They also found that ACT scores correlated with *g* estimated from the Armed Services Vocational Aptitude Battery (related to crystallized intelligence) at 0.77 and with a Raven's-derived IQ score (related to fluid intelligence) at 0.61. These authors concluded that the ACT test can be considered a measure of general intelligence. Coyle and Pillow (2008) provided additional results along these lines. When estimating *g* on the basis of a wide set of ability tests, the *g* loading for the ACT test was 0.92 and this figure was higher than any other test that was administered, including the Wonderlic (0.74) and the Raven's test of fluid intelligence (0.43). Any particular test, such as the ACT test, will have limitations in measuring *g* as a higher-order factor (Haier et al., 2009), but the ACT test is considered to be a good estimate of such abilities nonetheless (Wai et al., 2018). Given that the vast majority of our students had recently taken the ACT test, we asked for such scores as a way of capturing, approximately at least, individual difference variations in GCA (Wai et al., 2018).

Our IRB-approved protocols did not permit us to obtain official ACT scores from the registrar. Accordingly, we asked participants to self-report their ACT scores, given that Cole and Gonyea (2010) found a 0.95 correlation between self-reports of ACT scores and official ACT scores. That is, there appears to be very good memory for such scores (Cole & Gonyea, 2010) in the context of minimal tendencies toward over-reporting (Gramzow & Willard, 2006). It is also worth stating that participants had typically taken the test recently, that scores were entered into a computer program rather than reported to the experimenter (Tourangeau, Rips, & Rasinski, 2000), and that the question ("What was your ACT score?") was embedded in a general demographics survey concerned with factual questions related to sex, age, and other characteristics.

The research was conducted at a university that seeks to admit the vast majority of student applicants (94% in 2020) and the range of ACT scores was large in all studies. In Study 1a, participants' ACT scores ranged from 16 (28th percentile) to 35 (99th percentile), with a means of 23.74 (74th percentile) and a standard deviation of 3.34. Statistics were similar in Studies 1b (*M* = 23.23; *SD* = 3.30; range = 17–34), 1c (*M* = 22.77; *SD* = 3.69; range = 15–34), and 1d (*M* = 23.46; *SD* = 3.89; range = 16–34). In other words, variations in general cognitive ability were substantial and range restriction was not of particular concern. It is also useful to note that average scores were not higher than those reported by the university for the years that the studies were conducted (*Ms* = 24 and 23.7), attesting to the lack of self-enhancement concerning self-reports of these scores (Gramzow & Willard, 2006). Additional evidence concerning this point will be made with respect to the Study 1a protocol, which included several assessments useful in understanding the findings.

2.4. Additional Study 1a assessments

Gramzow and Willard (2006) found that self-enhancement tendencies affected reports of current college grades, but did not affect reports concerning college placement exam scores. To investigate similar processes in Study 1a, we administered a short form of the Balanced Inventory of Desirable Responding (Paulhus, 1984), which assesses two forms of socially desirable responding termed self-deceptive enhancement (an unconscious tendency toward self-enhancement) and impression management (a conscious tendency to alter reports such that they are pleasing to others). Such tendencies were assessed with the BIDR-16 (Hart, Ritchie, Hepper, & Gebauer, 2015), which asks individuals how much they agree (1 = not true; 7 = very true) with 8 statements each designed to tap self-deceptive enhancement (e.g., "I always know why I like things": *M* = 4.32; *SD* = 0.81; α = 0.56) and impression management (e.g., "I never take things that don't belong to me": *M* = 4.10; *SD* = 0.95; α = 0.68). Self-reports of ACT scores, in Study 1a, were not significantly correlated with self-deceptive enhancement, $r = 0.14$, $p = .174$, or impression management, $r = 0.06$, $p = .537$, and self-deceptive enhancement and impression management were not correlated with the ACT-related dynamic signatures reported below, all *ps* > 0.150. On the basis of these results, we conclude that tendencies toward socially desirable responding were not responsible for the results that were observed.

The Study 1a protocol, and only the Study 1a protocol, also included assessments of all of the Big 5 traits of personality, which is a comprehensive framework for understanding personality-related variations (McCrae & Costa Jr., 2008). We administered the Goldberg (1999) Big 5 scales, which have been used in many previous studies (Robinson & Gordon, 2011) and which correlate highly with alternative Big 5 assessments, such as those of the NEO-PI or BFI (John & Srivastava, 1999). Participants reported on their levels of agreement (1 = very inaccurate; 5 = very accurate) with statements that capture variations in extraversion (e.g., "am the life of the party": *M* = 3.30; *SD* = 0.81; α = 0.90), agreeableness (e.g., "have a soft heart": *M* = 4.20; *SD* = 0.54; α = 0.86), conscientiousness (e.g., "am always prepared": *M* = 3.78; *SD* = 0.66; α = 0.88), neuroticism (e.g., "get upset easily": *M* = 2.69; *SD* = 0.80; α = 0.89), and openness to experience (e.g., "have excellent ideas": *M* = 3.25; *SD* = 0.48; α = 0.80). Conscientiousness has been linked to academic success (Corker, Oswald, & Donnellan, 2012), but intelligence tests tend to correlate with openness to experience to a greater extent (Anglim et al., 2022). Findings of this type will be saved for the Results section.

2.5. Dynamic Affect Reactivity Task (DART)

We administered the Dynamic Affect Reactivity Task (DART), which is a task that is capable of isolating emotion onsets, peaks, and the velocity of affect change in real-time reports of emotional responding (Irvin et al., 2023; Klein, Jacobson, & Robinson, 2023). Stimuli for the task consisted of images from the International Affective Picture System (IAPS: Lang et al., 2005), which have been shown to elicit physiological, neural, and subjective affective reactions in many previous studies (Lang, 1995; Lang & Bradley, 2010). Based on norms reported by Lang et al. (2005), we selected pleasant and unpleasant images that differed by valence, all *Fs* > 400, but not arousal or extremity (distance from valence midpoint), all *Fs* < 1.

Of importance, we sought replication and therefore ran versions of the basic paradigm four times. These versions of the paradigm varied in terms of number of stimuli and timing parameters, which can bolster confidence in the robustness of the phenomena of interest (Brandt et al., 2014). Beyond this point, we should admit that alterations were largely made in an intuitive manner and/or because of time constraints. That is, we do not regard variations across replications to be theoretically important, although we do take advantage of the longer nature of the Study 1d task in exploratory analyses (see below). Study 1a presented 24 images (pleasant image valence *M* = 7.45; unpleasant image valence *M* = 2.50), Study 1b presented 20 images (valence *Ms* = 7.46 and 2.57), Study 1c presented 32 images (valence *Ms* = 7.24 and 2.72), and Study 1d presented 60 images (valence *Ms* = 7.51 and 2.49). Pleasant images had diverse themes (e.g., cute animals, money, sports, landscapes, sexual activity), as did unpleasant images (e.g., dangerous animals, dead animals, morally repugnant behaviors, filthy environments).

Instructions for the DART (for all samples) stated that we were interested in subjective or personal emotional reactions to a series of images. Participants were asked to indicate how pleasant or unpleasant their feelings were by moving a standard PC computer mouse (Girard, 2014) whenever they noticed their feelings becoming more pleasant or unpleasant. As the mouse was moved, position changes were displayed on a prominent vertical rating bar, presented to the right side of the screen, which was labeled "Very Pleasant" on one side (either top or bottom, depending on a counterbalancing procedure), "Very Unpleasant" on the other, and "Neutral" in the middle. Positions along this continuum were echoed by a position bar that was white when centered, green when pleasant feelings were experienced, and red when unpleasant feelings were experienced. The computer program recorded 1001 unique positions and mouse position was sampled 10 times a second (i.e., every 100 ms).

In Study 1a, an initial screen, presented for 1.5 s, asked participants to "get ready to rate your emotional reactions to the image". An image was then randomly selected and displayed for 5 s. Subsequently, there was a 10 s blank interval, but participants were asked to continue rating their feelings during this time period. In Study 1b, affective images were shown for 4 s and each trial was buffered with 22 s of a neutral image (e.g., a picture of a fork or a cup). Study 1c procedures were similar to Study 1a procedures, except that the blank interval was 6 s and the "get ready" slide was presented for 4.5 s. In Study 1d, the "get ready" slide was presented for 2 s, a randomly selected affective image was presented for 4 s, and the post-offset buffer period was 15 s. In each case, mouse position was re-centered prior to the display of an affective image. In each case, also, the experiment ended after each participant had viewed each affective image one time and image orders were randomized at the participant-specific level.

Given that affect position was recorded 10 times a second and given that mouse positions are a bit noisy (but sensitive: Girard, 2014), we used algorithms, which are now invariant across studies, to isolate feeling onset and feeling peak for each trial (Irvin et al., 2023, discuss these algorithms in detail, which were developed on the basis of an iterative procedure involving matching algorithm output to visual coding for a randomly selected set of trials, which were then applied, through the use of MATLAB, to all trials: Luck, 2012). Feeling onset was defined in terms of the first time point that was followed by 2 successful movement changes in a direction consistent with image valence (e.g., in a pleasant direction for a positive image), provided that the average of these movements was at least 4 (thus distinguishing intentional movements from noise). Peaks were defined in asymptotic terms, such that 3 feeling changes following onset had a value of 0 and 4 subsequent change scores averaged <1 in the valence-defined direction (Irvin et al., 2023). Peak time was the first of these 7 change scores and peak position was mouse position at peak time. See Irvin et al. (2023) for further details and their rationale.

As expected (Irvin et al., 2023), the algorithms failed to identify onsets and/or peaks on a number of trials and a visual inspection of these trials indicated that no discernible reactions occurred. Because key analyses focused on onsets, peaks, and velocities (see below), these trials on which no discernable reactions occurred (7.81% in Study 1a) were dropped, though drop rates will also be analyzed. Both time-based measures – onset time and peak time – were positively skewed and we therefore log-transformed these variables for analysis purposes, though millisecond means will be reported in characterizing significant effects (Robinson, 2007). Having log-transformed the time variables, we could now calculate the central affect change variable – namely, velocity of affect change from onset to peak, calculated in terms of change in distance (onset to peak) divided by change in log time (onset to peak). This parameter is akin to the "rise time to peak" parameter suggested by Davidson (1998) and it indexes a hot, dynamic form of emotional reactivity according to previous analyses (Robinson, Klein, & Irvin, 2023).

As will be reported below, ACT scores were predictive of the peak log time, peak amplitude, and velocity parameters. To estimate the reliability of these indices, we retained trial-level information and calculated an alpha coefficient for each parameter for each study (after multiplying amplitudes and velocities for aversive stimuli by −1). The reliability estimates for the peak log (αs = 0.91, 0.77, 0.90, and 0.94 for Studies 1a-1d, respectively), peak amplitude (αs = 0.84, 0.83, 0.92, and 0.97), and affect velocity (αs = 0.89, 0.85, 0.92, and 0.96) parameters were acceptable to good. Thus, the DART can (and did) capture these parameters in a reliable manner (also see Klein, Rapaport, Gyorda, Jacobson, & Robinson, 2023).

To speak to the validity of the DART paradigm, we correlated average peak amplitude values for each of the images shown in the present experiments with Lang et al. (2005) norms for valence. These correlations were 0.98, 0.98, 0.98, and 0.99 in Studies 1a-1d respectively. Hence, reactions in the paradigm were highly correlated with norms for the images. Additional validity evidence comes from previous studies using the DART paradigm. Following from the idea that negative reactions tend to be stronger and more peaked than positive reactions (Watson, 2000), several studies have found that negative reactions in the DART, relative to positive reactions, tend to start faster and/or reach higher peak amplitudes (Irvin et al., 2023; Robinson et al., 2021). Sex differences in threat sensitivity have been proposed (Campbell, 2013) and observed (Fetchenhauer & Buunk, 2005; McLean & Anderson, 2009) in multiple literatures and Robinson, Klein, and Irvin (2023) showed that women were more threat sensitive in the DART than men, particularly with respect to parameters like peak amplitude and velocity of affect change. More direct measures of threat and reward sensitivity have also been shown to modulate responding in theory-consistent manners. For example, Robinson et al. (2021) found that individuals with higher levels of Behavioral Inhibition (Carver & White, 1994) exhibited faster onsets for threatening images and individuals with higher levels of Behavioral Activation (Carver & White, 1994) reported stronger reactions when pleasant or appetitive stimuli were involved.

Finally, scores from the DART have been shown to predict emotion-related tendencies exhibited in daily life. For example, Klein, Jacobson, and Robinson (2023) found that individuals who reported stronger positive reactions to pleasant images experienced higher levels of positive emotion and well-being in their daily lives and Klein, Rapaport, et al. (2023) found that greater reactivity tendencies in the DART predicted greater reactivity to the best and worst events of the day in another daily diary protocol. Altogether, multiple sources of data have validated the DART paradigm in multiple manners.

2.6. *Analyses*

To place positive and negative trials on the same metric, peak displacements and velocities involving aversive stimuli were multiplied by −1. We then computed participant-specific averages by valence for drop rates, onset times, peak times, peak displacements, and velocities. We could then analyze all parameters as a function of the within-subject factor of valence in combination with a z-scored ACT continuum. Initial analyses took the form of General Linear Models (GLMs), which can simultaneously model repeated factors in combination with an individual difference continuum (Robinson, 2007).

3. Results

3.1. *Drop rates*

Drop rates were analyzed as a function of the ACT continuum, stimulus valence, and their interaction. The algorithms were equally successful across the ACT continuum, in that main effects for ACT were not observed in Study 1a, $F(1,100) = 2.72, p = .102, \eta_p^2 = 0.03$, Study 1b, $F(1, 149) = 0.39$, $p = .536$, $\eta_p^2 = 0.00$, Study 1c, $F(1,133) = 0.39$, $p = .532$, $\eta_p^2 = 0.00$, or Study 1d, $F(1, 117) = 1.20, p = .275, \eta_p^2 = 0.01$. That is, general cognitive ability did not matter with respect to exhibiting reactions that could be coded.

On the other hand, main effects for valence were observed in Studies 1a, $F(1, 100) = 29.98$, $p < .001$, $\eta_p^2 = 0.23$, 1b, $F(1, 149) = 14.72$, $p < .001$, $\eta_p^2 = 0.09$, 1c, $F(1, 133) = 49.38$, $p < .001$, $\eta_p^2 = 0.27$, and 1d, $F(1, 117) = 21.05$, $p < .001$, $\eta_p^2 = 0.15$. Consistent with the analysis of Irvin et al. (2023), reactions to negative stimuli appeared to be more obligatory than reactions to positive stimuli, as defined by lower drop rates for negative than positive stimuli in Studies 1a (positive $M = 10.46\%$; negative $M = 5.15\%$), 1b (positive $M = 10.46\%$; negative $M = 5.63\%$), 1c (positive $M = 9.75\%$; negative $M = 4.39\%$), and 1d (positive $M = 15.60\%$; negative $M = 9.72\%$).

Potential interactions between ACT scores and valence were not observed in Study 1a, $F(1, 100) = 0.00$, $p = .973$, $\eta_p^2 = 0.00$, Study 1b, $F(1, 149) = 0.19$, $p = .662$, $\eta_p^2 = 0.00$, or Study 1d, $F(1, 117) = 0.00$, $p = .946$, $\eta_p^2 = 0.00$, though an interaction was observed in Study 1c, $F(1, 133) = 7.39$, $p = .007$, $\eta_p^2 = 0.05$. Estimated means (+/− 1 *SD*) in combination with simple slopes analyses (Robinson, 2007) indicated that the valence effect was significant at both low (estimated positive and negative *M*s = 8.22% versus 4.78%), $t = 3.03$, $p = .003$, and high (estimated positive and negative *M*s = 11.24% versus 3.44%), $t = 6.89$, $p < .001$, levels of the ACT continuum, but that the valence effect, for drop rates, was somewhat stronger as ACT scores increased.

3.2. Onset times

Emotion onset times did not vary by ACT scores in Study 1a, $F(1, 100) = 0.97$, $p = .327$, $\eta_p^2 = 0.01$, Study 1b, $F(1, 149) = 0.51$, $p = .477$, $\eta_p^2 = 0.00$, Study 1c, $F(1, 133) = 1.18$, $p = .279$, $\eta_p^2 = 0.01$, or Study 1d, $F(1, 117) = 0.08$, $p = .779$, $\eta_p^2 = 0.00$. A main effect for valence was observed in Study 1b, $F(1, 149) = 88.21$, $p < .001$, $\eta_p^2 = 0.37$, and Study 1c, $F(1, 133) = 82.67$, $p < .001$, $\eta_p^2 = 0.38$, but not Study 1a, $F(1, 100) = 2.66$, $p = .106$, $\eta_p^2 = 0.05$, or Study 1d, $F(1, 117) = 0.01$, $p = .941$, $\eta_p^2 = 0.00$. In Studies 1b (positive $M = 2524$ ms; negative $M = 1914$ ms) and 1c (positive $M = 1704$ ms; negative $M = 1426$ ms), reaction onsets were quicker when negative stimuli were involved.

The ACT by valence interaction was significant in Studies 1a, $F(1, 100) = 4.75$, $p = .032$, $\eta_p^2 = 0.05$, and 1b, $F(1, 149) = 8.21$, $p < .001$, $\eta_p^2 = 0.05$, but not Studies 1c, $F(1, 133) = 0.57$, $p = .454$, $\eta_p^2 = 0.00$, or 1d, $F(1, 117) = 1.96$, $p = .164$, $\eta_p^2 = 0.02$. We used estimated means and simple slopes analyses (Aiken & West, 1991) to decompose the interactions that occurred. In Study 1a, a negativity effect was observed at high (estimated positive and negative *M*s = 2108 and 1830), $t = 3.02$, $p = .003$, but not low (estimated positive and negative *M*s = 1968 and 1957), $t = 0.44$, $p = .661$, levels of the ACT continuum. In Study 1b, a negativity effect was present at both low (estimated positive and negative *M*s = 2357 and 1964), $t = 4.57$, $p < .001$, and high (estimated *M*s = 2694 and 1865), $t = 8.61$, $p < .001$, levels of the ACT continuum.

3.3. Peak times

After onset, emotional response patterns appeared to diverge by general cognitive ability (as indexed by the proxy of ACT scores). The main effect for ACT scores was significant in Study 1a, $F(1, 100) = 8.68$, $p = .004$, $\eta_p^2 = 0.08$, Study 1c, $F(1, 133) = 10.49$, $p = .002$, $\eta_p^2 = 0.07$, and Study 1d, $F(1, 117) = 5.28$, $p = .023$, $\eta_p^2 = 0.04$, and it was marginally significant in Study 1b, $F(1, 149) = 3.17$, $p = .077$, $\eta_p^2 = 0.02$. In all cases, estimated means (±1 *SD*) revealed that participants with higher levels of cognitive ability took longer to reach their peaks (Study 1a: 3105 ms; Study 1b: 3351 ms; Study 1c: 2654 ms; Study 1d: 2480 ms) than participants with lower levels of cognitive ability did (Study 1a: 2668 ms; Study 1b: 3071 ms; Study 1c: 2340 ms; Study 1d: 2292 ms).

A main effect for valence was observed in Study 1b (positive $M = 3470$ ms; negative $M = 2968$ ms), $F(1, 149) = 43.79$, $p < .001$, $\eta_p^2 = 0.23$, and Study 1c (positive $M = 2645$ ms; negative $M = 2337$ ms), $F(1, 133) = 75.95$, $p < .001$, $\eta_p^2 = 0.36$, but not Study 1a, $F(1, 100) = 0.81$, $p = .369$, $\eta_p^2 = 0.01$, or Study 1d, $F(1, 117) = 2.75$, $p = .100$, $\eta_p^2 = 0.02$. The studies that exhibited a main effect for valence for peak times were the same studies that exhibited a main effect for valence for onset times, suggesting that negative peak times were faster in these studies because negative onset times were faster. Of perhaps more importance, ACT by valence interactions were not observed in Studies 1a, $F(1, 100) = 1.35$, $p = .249$, $\eta_p^2 = 0.01$, 1b, $F(1, 149) = 2.52$, $p = .114$, $\eta_p^2 = 0.02$, 1c, $F(1, 133) = 0.20$, $p = .657$, $\eta_p^2 = 0.00$, or 1d, $F(1, 117) = 0.00$, $p = .954$, $\eta_p^2 = 0.00$. That is, there was a general, rather than valence-specific, tendency toward slower peaks at higher levels of cognitive ability.

3.4. Peak displacements

In addition to slower peaks, participants with higher levels of cognitive ability displayed peak reactions that were more muted. Specifically, there was a main effect for ACT scores in Studies 1a, $F(1, 100) = 13.23$, $p < .001$, $\eta_p^2 = 0.12$, 1b, $F(1, 149) = 11.45$, $p < .001$, $\eta_p^2 = 0.07$, 1c, $F(1, 133) = 4.46$, $p = .037$, $\eta_p^2 = 0.03$, and 1d, $F(1, 117) = 8.65$, $p = .004$, $\eta_p^2 = 0.07$. In all cases, estimated means indicated that affective peaks for individuals with high cognitive ability were less pronounced (Study 1a: 313; Study 1b: 273; Study 1c: 277; Study 1d: 293) than affective peaks for individuals with low cognitive ability (Study 1a: 362; Study 1b: 318; Study 1c: 307; Study 1d: 341).

A main effect for valence was also observed in all studies. Relative to positive peaks, negative peaks were more pronounced in Studies 1a (positive and negative *M*s = 288 and 377), $F(1, 100) = 101.14$, $p < .001$, $\eta_p^2 = 0.50$, 1b (positive and negative *M*s = 243 and 347), $F(1, 149) = 156.95$, $p < .001$, $\eta_p^2 = 0.51$, 1c (positive and negative *M*s = 255 and 331), $F(1, 133) = 122.96$, $p < .001$, $\eta_p^2 = 0.48$, and 1d (positive and negative *M*s = 290 and 340), $F(1, 117) = 62.98$, $p < .001$, $\eta_p^2 = 0.35$. That is, despite equating positive and negative stimuli for arousal and extremity, negative peaks were nonetheless more pronounced than positive peaks. These data accord with the analysis of Watson (2000), who suggests that negative reactions tend to be more irruptive and peaked than positive reactions are.

Of importance, ACT by valence interactions were not observed in Studies 1a, $F(1, 100) = 0.05$, $p = .823$, $\eta_p^2 = 0.00$, 1b, $F(1, 149) = 0.35$, $p = .556$, $\eta_p^2 = 0.00$, 1c, $F(1, 133) = 2.17$, $p = .143$, $\eta_p^2 = 0.02$, or 1d, $F(1, 117) = 0.00$, $p = .979$, $\eta_p^2 = 0.00$. Thus, the muted reactions of individuals with higher levels of cognitive ability were observed regardless of whether stimuli were appetitive or aversive.

3.5. Velocity of affect change

The preceding results suggest that the velocity of affect change is likely to be more sluggish at higher levels of general cognitive ability. This expectation was confirmed by the fact that affect velocities varied by ACT scores in Study 1a, $F(1, 100) = 21.62$, $p < .001$, $\eta_p^2 = 0.18$, Study 1b, $F(1, 149) = 5.36$, $p = .022$, $\eta_p^2 = 0.03$, Study 1c, $F(1, 133) = 10.20$, $p = .002$, $\eta_p^2 = 0.07$, and Study 1d, $F(1, 117) = 8.87$, $p = .004$, $\eta_p^2 = 0.07$. As indicated by the estimated means (+/− 1 *SD*) displayed in Fig. 1, affect velocities were lower at higher levels of cognitive ability in Study 1a (left top panel), Study 1b (right top panel), Study 1c (left bottom panel), and Study 1d (right bottom panel).

Main effects for valence were also observed, such that negative affect velocities were higher than positive affect velocities. This was true in Study 1a (positive and negative *M*s = 2732 and 3578), $F(1, 100) = 44.18$, $p < .001$, $\eta_p^2 = 0.31$, Study 1b (positive and negative *M*s = 2647 and 3314), $F(1, 149) = 16.36$, $p < .001$, $\eta_p^2 = 0.10$, Study 1c (positive and negative *M*s = 2144 and 2661), and Study 1d (positive and negative *M*s = 1889 and 2201), $F(1, 117) = 18.01$, $p < .001$, $\eta_p^2 = 0.13$.

Finally, ACT by valence interactions were not observed in Studies 1a, $F(1, 100) = 2.68$, $p = .105$, $\eta_p^2 = 0.03$, 1b, $F(1, 149) = 0.07$, $p = .788$, $\eta_p^2 = 0.00$, or 1c, $F(1, 133) = 1.17$, $p = .282$, $\eta_p^2 = 0.01$, though an ACT by valence interaction did occur in Study 1d, $F(1, 117) = 5.11$, $p = .026$, $\eta_p^2 = 0.04$. This interaction was subtle and the ACT effect was significant for

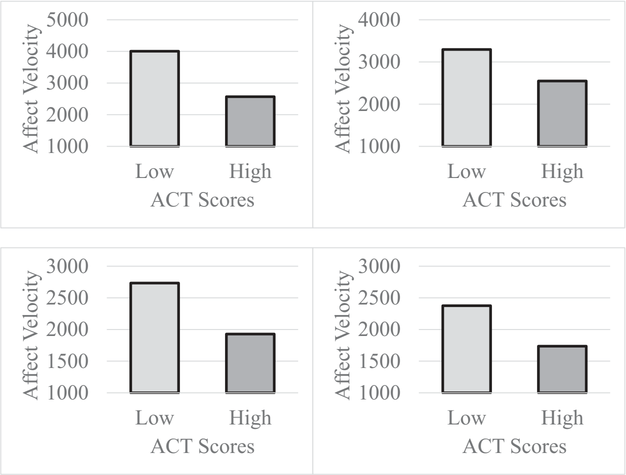

Fig. 1. Affect Velocities as a Function of General Cognitive Ability (ACT Scores), Estimated Means for Studies 1a (left, top), 1b (right, top), 1c (left, bottom), and 1d (right, bottom).

both positive (estimated *Ms* at low versus high levels of cognitive ability $= 2122$ versus 1655), $t = -2.18$, $p = .031$, and negative (estimated *Ms* at low versus high levels of cognitive ability $= 2601$ versus 1800), $t = -3.40$, $p < .001$, emotional reactions. The general conclusion is therefore that participants with higher levels of cognitive ability exhibited slower affect velocities irrespective of the valence of stimuli they were exposed to.

3.6. Additional analyses of Study 1d data

Sixty stimuli were shown in Study 1d and this permitted an examination of possible trends related to time on task. For these analyses, we computed means by valence and time on task (first 30 trials versus second 30 trials), while including the z-scored ACT continuum, in a series of GLMs (Robinson, 2007). With respect to onset times, there was no main effect for time on task, $F(1, 117) = 0.02$, $p = .887$, $\eta_p^2 = 0.00$, and higher-order interactions involving the time on task variable were not significant, $Fs < 1$, $ps > 0.400$. Hence, there was no indication that emotional onsets became faster as the task progressed.

With respect to peak times, there was a marginal main effect for time on task (*Ms* = 2420 and 22,362 for earlier versus later trials), $F(1, 117) = 3.57$, $p = .061$, $\eta_p^2 = 0.03$. However, there were no two-way or three-way interactions involving this variable, $Fs < 1$, $ps > 0.700$. Thus, the relationship between ACT scores and (slower) peak times was observed both initially and after considerable practice with the task. The time on task variable did not affect peak amplitudes, either as a main effect or in interactive terms, $Fs < 1$, $ps > 0.500$.

Velocities of affect change were similarly not affected by time on task, $F(1, 117) = 2.48$, $p = .118$, $\eta_p^2 = 0.02$. There was a marginally significant time on task by valence interaction, $F(1, 117) = 3.05$, $p = .083$, $\eta_p^2 = 0.03$, such that velocities became faster, from earlier to later trials, when aversive stimuli (*Ms* = 2099 versus 2305) were presented, relative to appetitive stimuli (*Ms* = 1877 versus 1893). But two- and three-way interactions involving ACT levels were not significant, $Fs < 1$, $ps > 0.350$. The most important conclusion from these analyses is that relationships between the ACT continuum and indicators of sluggish reactivity were equally evident throughout the task, pointing to variations in affective style that appear to be robust.

3.7. Discriminant validity with respect to personality traits

In Study 1a, we assessed individual differences in all of the Big 5 traits. Consistent with a recent meta-analysis (Anglim et al., 2022), we found that (self-reported) ACT scores correlated positively with openness to experience, $r = 0.26$, $p = .007$, and negatively with the trait of neuroticism, $r = -0.23$, $p = .023$. General cognitive ability (as assessed by the proxy of ACT scores) was unrelated to extraversion, $r = -0.01$, $p = .937$, agreeableness, $r = -0.09$, $p = .352$, and conscientiousness, $r = 0.04$, $p = .678$. This Big 5 profile accords with Anglim et al. (2022).

Recall that we observed main effects for ACT scores with respect to the peak time, peak amplitude, and affect velocity parameters. These main effects were replicated when averaging across all trials of the Study 1a task and then correlating ACT scores with these averages (peak log times: $r = 0.28$, $p = .004$; peak amplitudes: $r = -0.34$, $p < .001$; velocity of affect change: $r = -0.42$, $p < .001$). Extraversion predicted velocity, $r = 0.23$, $p = .022$, but not peak time, $r = 0.09$, $p = .374$, or amplitude, $r = 0.13$, $p = .195$. Agreeableness predicted amplitude, $r = 0.20$, $p = .041$, but not peak time, $r = -0.12$, $p = .217$, or velocity, $r = 0.09$, $p = .383$. Conscientiousness also predicted amplitude, $r = 0.27$, $p = .005$, but not peak time, $r = -0.17$, $p = .085$, or velocity, $r = 0.19$, $p = .055$. Neuroticism predicted peak time, $r = -0.28$, $p = .004$, but not amplitude, $r = 0.17$, $p = .085$, or velocity, $r = 0.15$, $p = .146$. Openness to experience did not matter for peak time, $r = 0.12$, $p = .231$, amplitude, $r = 0.04$, $p = .725$, or velocity, $r = -0.10$, $p = .315$. Overall, then, the ACT continuum displayed the most consistent relationship with the parameters of interest.

We then performed three multiple regressions, with ACT scores and all of the Big 5 personality traits as simultaneous predictors of a given DART parameter. Of most importance, ACT scores continued to predict peak times, $b = 0.021$ [0.003, 0.039], $t = 2.33$, $p = .022$, $\beta = 0.23$, peak amplitudes, $b = -22.050$ [-34.319, -9.7890], $t = -3.57$, $p < .001$, $\beta = -0.34$, and velocity scores, $b = -608.695$ [-893.643, -323.747], $t = -4.24$, $p < .001$, $\beta = -0.39$, when controlling for all of the Big 5 personality traits. These analyses demonstrate the discriminant validity of the present patterns. That is, the muted affective responses of individuals with higher ACT scores cannot ascribed to variations in their personality traits.

4. Discussion

Watson (2000) suggested that the negative affective system appears to be more sensitive to situational input and Taylor (1991) concluded that reactions to aversive stimuli tend to be stronger than reactions to appetitive stimuli. Findings from the DART provide unique evidence in support of these ideas. Despite equating stimuli for arousal and extremity, algorithms were more successful in identifying emotional reactions when aversive stimuli were involved and peak intensities were higher with respect to unpleasant relative to pleasant reactions. The rate of affective change from onset to peak (velocity) was also more pronounced when negative stimuli were involved. These results provide additional evidence in support of the idea that negative reactions to aversive stimuli may be more mandatory than positive reactions to appetitive stimuli, likely reflecting evolved mechanisms that are threat-sensitive (Irvin et al., 2023).

Independent of this valence effect, variations in general cognitive ability were also implicated in reactivity profiles. In particular, when an affective system was engaged (post-onset), individuals with higher levels of general cognitive ability displayed more muted affective change. They displayed delayed peaks (in 3 of 4 studies), peak intensities that were lower, and velocity changes (from onset to peak) that were less pronounced. These main effects did not generally interact with valence and when valence interactions were observed, they did not implicate the down-regulation of negative emotion in particular. Accordingly, we conclude that there appears to be lesser “heat” to the emotional reactivity systems of individuals with higher levels of general cognitive ability, almost certainly due to cognitive processes (such as distancing or abstract thought) that mitigate emotional arousal. Although replication across samples was strong, we sought to conduct one additional study.

5. Study 2

In their studies of dynamic affect, Larsen and McGraw (2011) recommended using both mouse movement and button press technologies, each of which has advantages and limitations. Mouse movements can be made quickly, but some presence of motor noise is almost certainly present when using this effector (Slifkin & Newell, 1998). Button presses are likely to be voluntary, but they are not continuous and pressing a button can lag behind intentions to make a response (Ulrich, Mattes, & Miller, 1999). Regardless, replication across the two effectors would provide greater confidence in the findings (Larsen & McGraw, 2011) and we therefore asked participants to indicate affect change with button presses in Study 2. In addition, we presented participants with affective images from a more recent database – the Nencki Affective Picture System (NAPS: Marchewka, Żurawski, Jednoróg, & Grabowska, 2014).

6. Method

6.1. Participants and general procedures

Power considerations were identical to prior studies and we sought a sample size of >84. Undergraduate students seeking credit for their psychology classes signed up for a personality and emotion study using SONA software. They arrived to the laboratory in groups of 6 or fewer, completed informed consent, and then the experiment proper in private computer rooms with personal computers. The affect dynamic task was programmed with *E*-Prime software and ACT scores were collected using MediaLab. A total of 124 participants (74.19% female; 93.55% White; *M* age = 18.73) reported ACT scores and completed the study.

6.2. General cognitive ability

General cognitive ability was assessed in approximate terms by (self-reported) ACT scores (Koenig et al., 2008) at a university with high admissions rates (94% in 2020). Such scores varied from 18 (41st percentile) to 36 (100% percentile), with a mean of 23.33 (70th percentile) and a standard deviation of 3.30.

6.3. Dynamic Affect Reactivity Task (DART)

The DART task of Study 2 was similar to that of Study 1, though with two prominent changes. Rather than presenting IAPS images, some of which are dated, we presented images from the Nencki Affective Picture System (NAPS), which is a more modern set of images (Marchewka et al., 2014). In particular, the images are high-quality and each image has the same size (1600 by 1200 pixels). Using the norms of Marchewka et al. (2014), we selected 20 images, 10 of which were appealing (e.g., boy on slide, woman smiling, skaters, sports themes) and 10 of which were aversive (e.g., pollution, homelessness, bad accidents, rotten food). The images selected to be pleasant were more pleasant than those selected to be unpleasant, $F(1, 19) = 426.94$, $p < .001$, $\eta_p^2 = 0.96$, but did not differ in norms for arousal or extremity, $Fs < 1$.

Instructions for the DART were, for the most part, identical to Study 1, except that participants were instructed to indicate affect changes by pressing up or down arrows on the keyboard. Whether up arrow presses were linked to pleasant or unpleasant feelings was counterbalanced across participants. In either case, button presses moved a “current affect” cursor within a prominently displayed vertical affect rating bar presented toward the right side of the computer screen and participants were asked to make button presses to reflect current affective state and/or affective changes that occurred during the presentation of an image. Participants could make as many as 13 button presses in either the pleasant or unpleasant direction and the cursor was re-centered to “baseline feelings” (midpoint of scale) prior to the presentation of an affective image for the trial. As in Study 1, the computer program recorded positions in terms of a 1001-point rating scale (from “very pleasant” to “very unpleasant”) and current affect position was sampled 10 times a second.

On each trial, a “get ready” screen, which was presented for 3 s, asked participants to get ready to rate their emotional reactions the upcoming image. Subsequently, an affective image was selected at random (each participant had a different randomized order of images) and presented for 5 s. Following each affective image, a blue screen was presented for 60 s, serving as a buffer between affective reactions.

Onsets and peaks were scored using the button press algorithms developed by Irvin et al. (2023). Feeling onset was defined as the first button press in a direction consistent with image valence, provided that there was at least 1 subsequent movement in the same direction. Peak intensity was then defined in terms of the largest displacement that occurred subsequent to feeling onset, provided that all affect changes from onset to peak were in the same direction. The algorithms accorded with visual coding for a subset of trials (Luck, 2012) and we therefore applied them to all trials.

As in Study 1, onsets and peaks could not be calculated for a minority of the trials (10.69%) and these trials were dropped when computing the parameters of key interest (though we will also analyze drop rates when analyzing the other parameters). Onset times and peak times were positively skewed and we therefore computed log-transformed versions of these variables (Robinson, 2007). Velocity scores were then computed by dividing distance moved (onset to peak) by elapsed time (peak log time minus onset log time). Peak displacement and velocity scores for negative trials were then multiplied by −1, placing the positive and negative reactions on a comparable scale. In preparation for analyses, we computed participant- and valence-specific averages for each of the reactivity parameters.

As a final consideration, we considered questions of reliability and validity. The key DART parameters of peak log ($\alpha = 0.89$), peak amplitude ($\alpha = 0.86$), and velocity of affect change ($\alpha = 0.83$) were reliable across trials of the task. Additionally, we correlated average peak amplitudes for each of the images ($n = 20$) with NAPS norms for valence. This correlation was $r = 0.99$, $p < .001$, indicating substantial convergent validity.

7. Results

7.1. Drop rates

A General Linear Model analysis examined drop rates as a function of a z-scored version of the ACT score continuum, stimulus valence, and their interaction. There was no main effect for ACT scores, $F(1,122) = 0.05$, $p = .829$, $\eta_p^2 = 0.00$, and there was no ACT score by valence interaction, $F(1, 122) = 1.16$, $p = .285$, $\eta_p^2 = 0.01$. As in Study 1, a main effect for valence, $F(1, 122) = 88.18$, $p < .001$, $\eta_p^2 = 0.42$, occurred because participants were more likely to exhibit responses to negative stimuli (3.87% drop rate) relative to positive stimuli (17.50% drop rate).

7.2. Onset Times

The analysis of onset times focused on the log-transformed version of this variable, though millisecond means will be reported in the case of significant effects (Robinson, 2007). In this GLM, there was no main effect for ACT scores, $F(1, 122) = 0.10$, $p = .758$, $\eta_p^2 = 0.00$, and there was no ACT score by valence interaction, $F(1, 122) = 2.16$, $p = .144$, $\eta_p^2 = 0.02$. Thus, general cognitive ability does not appear to affect emotional onset processes to any considerable extent. On the other hand, a main effect for valence, $F(1, 122) = 98.03$, $p < .001$, $\eta_p^2 = 0.45$, indicated that emotional reactions to negative stimuli ($M = 1619$ ms) tended to begin more quickly than emotional reactions to positive stimuli ($M = 2463$ ms).

7.3. Peak times

Although variations in general cognitive ability were not associated with onset times, they were associated with peak times. A main effect for ACT scores, $F(1, 122) = 6.81$, $p = .010$, $\eta_p^2 = 0.05$, replicated Study 1, in that participants with higher levels of general cognitive ability reached peak reactivity at a later time (estimated $M = 6073$ ms) than participants with lower levels of general cognitive ability did (estimated $M = 5090$ ms). The main effect for valence was not significant, $F(1, 122) = 1.50$, $p = .223$, $\eta_p^2 = 0.01$, and the ACT by valence interaction was also not significant, $F(1, 122) = 0.21$, $p = .223$, $\eta_p^2 = 0.00$.

7.4. Peak displacements

Unlike Study 1, the main effect for ACT scores was not significant, $F(1, 122) = 0.07$, $p = .797$, $\eta_p^2 = 0.00$. Like Study 1, the main effect for valence was significant, $F(1, 122) = 164.57$, $p < .001$, $\eta_p^2 = 0.57$, such that negative peaks ($M = 322$) were higher than positive peaks ($M = 218$). The ACT by valence interaction was not significant, $F(1, 122) = 0.85$, $p = .360$, $\eta_p^2 = 0.01$, indicating that the negativity effect pertaining to peak displacements was preserved across cognitive ability levels.

7.5. Velocity of affect change

With respect to velocities of affect change, the main effect for ACT scores was significant, $F(1, 122) = 4.32$, $p = .040$, $\eta_p^2 = 0.03$. Estimated means revealed that individuals with higher, relative to lower, levels of cognitive ability displayed affect change velocities that were slower, as displayed in Fig. 2. In this analysis, there was also a main effect for valence, $F(1, 122) = 6.73$, $p = .011$, $\eta_p^2 = 0.05$, with the velocity of affect change being faster when negative ($M = 1785$) relative to positive ($M = 1216$) stimuli were involved. The ACT score by valence interaction was not significant, $F(1, 122) = 0.61$, $p = .436$, $\eta_p^2 = 0.00$. Thus, slower velocities were observed at higher levels of general cognitive ability with respect to both valences.

8. Discussion

Study 2 asked participants to indicate affect changes by making button presses and the results largely replicated those of Study 1, which asked individuals to make mouse movements. Negativity effects were observed for codability rates, onset times, peak reaction intensities, and velocities of affect change. As in Study 1, general cognitive ability did not matter with respect to onset-related processes. Subsequent to onset, though, individuals with higher levels of cognitive ability displayed delayed peak times and their affect change velocities were also less pronounced. These results suggest a less dynamic reactivity system at higher levels of general cognitive ability.

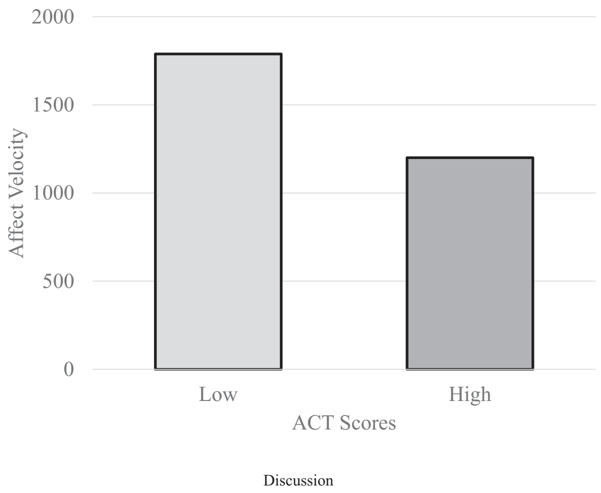

Fig. 2. Affect Velocity as a Function of General Cognitive Ability (ACT Scores), Estimated Means, Study 2.

9. General discussion

The circuits that generate emotion are thought, by some theorists, to be primitive and subcortical (Lang, Davis, & Öhman, 2000; Panksepp, 2005). Individuals who invest themselves in the cognitive domain, or whose skills are well-suited to this domain, may wish to distance themselves from their emotions, which represent echoes from the mammalian past (Lang et al., 2000; Panksepp, 2005). In the present investigation, we pursued ideas of this type by examining relationships between general cognitive ability, assessed using the proxy of ACT scores (Koenig et al., 2008), and reactivity patterns exhibited in a Dynamic Affect Reactivity Task (the DART: Klein, Jacobson, & Robinson, 2023). Participants with higher levels of general cognitive ability did not exhibit slower emotion onsets, but they did display slower peaks, peaks that were less intense, and/or velocities of affect change (from onset to peak) that were less pronounced. The results provide support for the idea that intelligent people appear to “cool” their affective reactions more habitually (Metcalfe & Mischel, 1999), possibly because they are less comfortable with them (Block & Kremen, 1996).

Before commencing with a further analysis of the present work, we should acknowledge that we assessed general cognitive ability in approximate terms. Although the ACT test appears to have a high *g* loading (Coyle & Pillow, 2008), it arguably assesses crystallized forms of intelligence to a larger extent than it assesses fluid forms of intelligence (Brown, 2016) and replication with tests such as the Raven's Advanced Progressive Matrices (Koenig et al., 2008) seems warranted. Of more importance, though, any particular cognitive ability test measures some combination of general intelligence and skills that are particular to the test in question (Gottfredson & Saklofske, 2009). To the extent that one wanted to make conclusions about how the general factor of intelligence operates, *g* should be estimated by a battery of tests that are known to be *g* loaded (Farmer, Floyd, Reynolds, & Berlin, 2020). We did not use this approach in the present studies and future studies of affective processing might do so.

9.1. Implications and analysis

A critical feature of emotions is that they change and there is growing interest in understanding these dynamic aspects of experience (Kuppens, 2015). A majority of this work has used daily diary or experience sampling methods to examine temporal aspects of experience (Houben, Van Den Noortgate, & Kuppens, 2015), but there is the need for laboratory models, which can examine short-term affective changes in a rigorous and controlled manner (Davidson, 2015). The Dynamic Affect Reactivity Task (DART) was created to fill this gap. It presents participants with affective images, with known emotion-inducing properties (Lang et al., 2005), that can be precisely timed (Irvin et al., 2023). By asking participants to continuously rate affect change during image exposure, and through the development of algorithms capable of parsing an affect stream into key change-related events, the DART is capable of examining several features of emotional reactivity.

Watson, 2000; Watson, Wiese, Vaidya, & Tellegen, 1999 has contended that there are likely to be key differences in the operations that produce positive and negative affect. When a threat presents itself, one must mobilize resources to avert that threat and negative emotional arousal facilitates this aim. Although appetitive behaviors (e.g., eating, drinking, socializing) must also be performed, they do not need to be performed at any particular time and the positive affective system should therefore tend to have a less reactive character. Results from the present studies provide support for such theorizing. In all studies, negative reactions were more discernable than positive reactions, with identifiable onsets and peaks. Negative reactions tended to have faster onsets and they always had more intense peaks as well as faster velocities. The velocity-related findings, which are novel to the current studies, highlight a certain degree of forcefulness to reactivity changes within the negative affect system.

In addition to main effects for valence, main effects for general cognitive ability were consistently observed. General cognitive ability did not influence the likelihood of having a reaction, and it did not influence how quickly a reaction started, but it did influence the nature of subsequent affect change. Participants with higher levels of cognitive ability displayed affect change that was delayed or muted (i.e., lesser in intensity). In all cases, such patterns were associated with lesser velocities of affect change – that is, lesser change in affect during the onset to peak interval. Because this interval captures the dynamic component of emotional reactivity (Davidson, 1998), the results suggest that individuals with higher levels of cognitive ability have less pronounced emotional reactivity, defined in terms of the velocity parameter. The findings were probably more compelling when affect change was indicated by mouse movements because mouse movements naturally allow for continuous updating (Girard, 2014), but findings were convergent when button presses were involved.

The results cannot be ascribed to cognitive achievements or motor movements per se because general cognitive ability has been linked to faster rather than slower responding in cognitive tasks (Gottfredson, 1998; Jensen & Munro, 1979). The results therefore implicate something about emotional reactivity in particular, which is less dynamic at higher levels of cognitive ability. The results should also not be ascribed to emotion regulation efforts at higher levels of cognitive ability because it is uncertain whether people spontaneously regulate their emotions in simple image reactivity tasks (Hendricks & Buchanan, 2016) and because spontaneous efforts at emotion regulation would typically be used to regulate one's negative emotional states to a greater extent than one's positive emotional states (Kalokerinos et al., 2017). Because negative emotional reactivity was more pronounced in the present tasks, the results do not implicate emotion regulation processes in any obvious manner. Of importance, furthermore, relations between general cognitive ability and affective velocities were generally equivalent by valence, implicating processes that relate to reactivity rather than regulation.

The findings involving general cognitive ability are probably best understood in dual process terms. For example, Epstein (2003) contrasts an experiential system, which is spontaneous and affective in nature, with a rational system, which is more resource-dependent and cognitive. General cognitive ability, which operates in manners consistent with the rational system (Evans, 2003), is likely to modulate the experiential system, in effect reducing its spontaneity. Such dynamics are probably most fully fleshed out in the hot-cool analysis of Metcalfe and Mischel (1999), according to which operations of the cool system (which is rational and strategic) can inhibit operations of the hot system (which is impulsive and emotional; also see Carver et al., 2009; Lieberman, 2003). Essentially, general cognitive ability would add meta-cognitive elements to what is essentially a more straightforward task involving emotional experiences, resulting in affect changes that are muted, delayed, or less "natural" (Panksepp, 2005).

Emotional reactions can be problematic (Parrott, 1995). For example, elevated forms of emotional reactivity are observed among individuals with borderline personality disorder (Carpenter & Trull, 2013) and they are also observed among individuals prone to self-harming behavior (Nock, Wedig, Holmberg, & Hooley, 2008). Indeed, Carver and colleagues (e.g., Carver, Johnson, & Timpano, 2017) suggest that a general factor of mental disorder exists and it consists of tendencies toward uncontrolled behaviors in the context of emotional arousal (Carver et al., 2009). From these perspectives, the higher levels of emotional reactivity exhibited by individuals with lower levels of cognitive ability could be regarded as problematic (Metcalfe & Mischel, 1999). This analysis accords with data indicating that higher levels of cognitive ability are linked to many positive outcomes, including health and longevity (Brown et al., 2021; Gottfredson & Deary, 2004).

However, other frameworks emphasize the functionality of the affect system (Epstein, 2003; Lench, Bench, Darbor, & Moore, 2015; Pham, Cohen, Pracejus, & Hughes, 2001) and blunted forms of emotional reactivity have been observed in multiple disorders such as schizophrenia (Evensen et al., 2012) and depression (Bylsma, 2021). In this context, it is thought that robust affective reactions are crucial to some forms of decision making (Bechara & Damasio, 2005) and behavioral self-regulation (Elliot, 2006; Klein, Jacobson, & Robinson, 2023). Evidence of this type was reported by Robinson, Klein, Irvin, and McGregor (2023), who found that individuals who attend to and value their feelings to a greater extent made self-regulatory choices that displayed greater affective rationality. Higher levels of cognitive ability could therefore be associated with some costs related to guidance by the affect system (Epstein, 2003). Given the apparent benefits and costs of robust affective reactions, however, the observed differences should probably be considered in terms of variations in "affective style" (Davidson, 1998), with their consequences deserving further attention.

10. Conclusions

Block (2002) suggested that there are psychological tradeoffs to self-control and the same may be true concerning variations in general cognitive ability. Although cognitive ability is clearly beneficial in many domains of life (Gottfredson, 1998), it is possible that the same operations and capacities could inhibit some elements of affective processing and reactivity. The results of the present studies encourage further investigations of this cognition-emotion interface.

Declaration of Competing Interest

None.

Data availability

the paper includes a link to datasets

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