American Psychological Association

Journal of Personality and Social Psychology:
Personality Processes and Individual Differences

© 2019 American Psychological Association
0022-3514/19/$12.00

2019, Vol. 117, No. 5, 1016–1033
http://dx.doi.org/10.1037/pspp0000257

Confused or Curious? Openness/Intellect Predicts More Positive Interest-Confusion Relations

Kirill Fayn
KU Leuven and Max Planck Institute for Empirical Aesthetics

Paul J. Silvia
University of North Carolina at Greensboro

Egon Dejonckheere, Stijn Verdonck, and Peter Kuppens
KU Leuven

Open people show greater interest in situations that are complex, novel, and difficult to understand—situations that may also be experienced as confusing. Here we investigate the possibility that openness/intellect is centrally characterized by more positive relations between interest and confusion. Interest and confusion are key states experienced during engagement with information and learning. However, little is known about the within-person relation between them, let alone individual differences in this relation. We tested our hypotheses by making use of different paradigms, stimuli, and participants. Across five studies ($N = 640$) we tested the relation between openness/intellect and within-person interest-confusion relations in response to art (Study 1); science, philosophy, and art (Study 2); psychology lectures (Study 3); a poem (Study 4); and a complex problem solving task (Study 5). Average interest-confusion relations varied between different studies, but for all studies the distributions of the relations went from highly negative to highly positive—individual differences in direction rather than just degree. In all but 1 study we found consistent support for our hypotheses—openness/intellect is associated with more positive relations between interest and confusion. No other personality domain or intelligence was consistently related to interest-confusion relations. Together, these findings suggest a new phenomenological aspect of being open—curiosity toward confusing situations. Our findings support the link between openness/intellect and sensitivity to the value of complex information, and are discussed with regards to their relevance for engagement with information and learning.

Keywords: interest, confusion, curiosity, openness to experience, openness/intellect

Supplemental materials: http://dx.doi.org/10.1037/pspp0000257.supp

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

The nomological net of openness/intellect—one of the major dimensions of personality—includes relations with intelligence, general knowledge, educational outcomes, creativity, curiosity, and investigative and artistic interests (Ackerman & Heggestad, 1997; Kaufman et al., 2016; Poropat, 2009). It is, therefore, no surprise that it has been described as a dimension of personality reflecting individual differences in cognitive exploration (De Young, 2015). While clearly an important construct for describing differences between people, we know relatively little about the phenomenological and within-person characteristics of openness/intellect compared with several other main dimensions of personality, such as extraversion or neuroticism. One central feature of highly open people is interest in sensory and abstract information. Particularly, open people are interested in complex, novel, and difficult to understand situations (Fayn, MacCann, Tiliopoulos, & Silvia, 2015; Fayn, Silvia, MacCann, & Tiliopoulos, 2017; Silvia, Henson, & Templin, 2009). Given that such situations are also more likely to induce confusion, here we investigate the possibility that openness/intellect is centrally characterized by a more positive/less negative[1] relation between interest and confusion. Thus, we aim to offer a key

This article was published Online First July 1, 2019.

Kirill Fayn, Faculty of Psychology and Educational Sciences, KU Leuven, and Department of Language & Literature, Max Planck Institute for Empirical Aesthetics; Paul J. Silvia, School of Psychology, University of North Carolina at Greensboro; Egon Dejonckheere, Stijn Verdonck, and Peter Kuppens, Faculty of Psychology and Educational Sciences, KU Leuven.

Support for this research was provided by the Research Fund of KU Leuven (GOA/15/003; C14/19/054), by the Interuniversity Attraction Poles program financed by the Belgian government (IAP/P7/06), the Postdoctoral Mandate KU Leuven (17073), and the Fund of Scientific Research Flanders (12M9617N). We thank Julian Provenzano and Yasemin Erbas for testing and commenting on the microworld task.

Correspondence concerning this article should be addressed to Kirill Fayn, Department of Language & Literature, Max Planck Institute for Empirical Aesthetics, Grüneburgweg 14, 60322 Frankfurt am Main, Germany. E-mail: kirill.fayn@ae.mpg.de

[1] Given that the range of interest-confusion relations were observed to go from highly positive to highly negative, throughout the rest of the manuscript we refer to positive associations between traits and interest-confusion relations as 'more positive,' and negative associations as 'more negative.'

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

insight into the experiences of those higher in openness/intellect in response to informational stimuli and situations.

Interest and confusion could be considered the most basic and important states experienced during engagement with information. Interest is an emotion that is experienced in learning and information processing contexts that is thought to motivate engagement and learning (Izard, 1977; Silvia, 2017; Tomkins, 1962). Confusion is also considered an emotion that is experienced in the same contexts as interest, but is a signal of an impasse in information processing that can ultimately lead to greater investment of resources or withdrawal (Silvia, 2009). The importance of these states is reflected by research that shows them to be two of the most frequently reported states during complex learning (D'Mello, 2013), and their association with learning gains (Craig, Graesser, Sullins, & Gholson, 2004; Schiefele & Csikszentmihalyi, 1994; D'Mello & Graesser, 2011; D'Mello, Lehman, Pekrun, & Graesser, 2014). Further, temporal transitions between interest and confusion during complex learning are the most frequently occurring transitions among various learning states (D'Mello & Graesser, 2012). While clearly important variables for engaging with information, little is known regarding the relation between interest and confusion, let alone individual differences in this relation.

The central hypothesis we put forward is that while on average interest and confusion will have a negative association, meaning that the experience of one reduces the possibility of experiencing of the other, this relation will be more positive for those higher in openness/intellect. That is, openness/intellect will be associated with less negative or even positive interest-confusion relations. The rationale for this hypothesis is based, broadly, on research showing that openness/intellect allows for higher levels of complexity in emotional experiences, and more narrowly, on findings showing that openness/intellect is associated with particular interest-appraisal relations that would allow for more positive relations between interest and confusion (Fayn, MacCann, et al., 2015; Fayn et al., 2017; Fayn, Tiliopoulos, et al., 2015; Silvia et al., 2009).

Openness/Intellect and Emotional Complexity

Emotional complexity has been a subject of great interest to emotion researchers, and this continues to be the case with growing research focus on complexity in the emotions field (Grossmann, Huynh, & Ellsworth, 2016; Grühn, Lumley, Diehl, & Labouvie-Vief, 2013). Two central aspects of emotion complexity are emotion differentiation and emotional bipolarity. Emotion differentiation refers to within-person relations between emotional experiences of the same valence. For example, some people differentiate between different negative emotions, while others tend to report many negative states at once (e.g., some tend to not feel sad when they feel anxious, whereas for others these feelings are coupled together). The tendency to differentiate between emotions is associated with lack of psychopathology and higher subjective well-being (Erbas, Ceulemans, Lee Pe, Koval, & Kuppens, 2014; Kashdan, Barrett, & McKnight, 2015). Emotional bipolarity is the study of within-person relations between opposite valenced emotions (e.g., some people tend to not report negative emotions when they report positive emotions, whereas others sometimes report both positive and negative emotions at the same time). For example, reduced bipolarity between positive and negative emotions is associated with situations that are less stressful, and with lower levels of depressive symptoms (Coifman, Berenson, Rafaeli, & Downey, 2012; Dejonckheere et al., 2018; Zautra, Berkhof, & Nicolson, 2002). While seemingly disparate, the two tendencies—emotion bipolarity and emotion differentiation—are bound in being indicators of a more nuanced experience with the eliciting situation. Most research on emotion complexity has been investigated emotions reported in daily life. The current investigation aligns with previous research in terms of a focus on complexity in emotional experiences, but with a focus on emotions typically experienced during engagement with information and learning.

Individual differences in emotional phenomena are traditionally the domain of extraversion and neuroticism, which strongly relate to experiences of positive and negative affect (Steel, Schmidt, & Shultz, 2008). Openness/intellect—the newcomer to describing individual differences in emotions—is associated with experiences of interest, awe, awe-inspired crying, immersion, absorption, and chills in response to various kinds of epistemic and aesthetic situations (Cotter, Silvia, & Fayn, 2018; Fayn et al., 2015; Fayn et al., 2015; Shiota, Keltner, & John, 2006; Silvia, Fayn, Nusbaum, & Beaty, 2015; Silvia & Nusbaum, 2011; Tellegen & Atkinson, 1974; Weibel, Wissmath, & Mast, 2010).

In terms of emotional complexity, openness/intellect—particularly openness to feelings, a lower order facet of the openness aspect—has been associated with reporting emotional experiences that align with the circumplex model of affect, compared with more bipolar and valence focused responding by those low on openness to feelings (Terracciano, McCrae, Hagemann, & Costa, 2003). Openness/intellect was also found to involve greater differentiation between negative emotions in response to visual art, leading to more nuanced experiences (Fayn, Silvia, Erbas, Tiliopoulos, & Kuppens, 2018). Of particular relevance to our hypothesis, openness/intellect is characterized by tolerance of ambiguity (Furnham & Marks, 2013; Jach & Smillie, 2019), greater likelihood of experiencing mixed emotions (Barford & Smillie, 2016), and mixed valence evaluations in response to visual art (Barford, Fayn, Silvia, & Smillie, 2018). Together, these findings suggest that openness/intellect is related to more complex and nuanced emotional experiences, which broadly informs our hypothesis that the relation between interest and confusion may vary as a function of openness/intellect.

Openness/Intellect, Interest, Confusion, and Appraisals

Our hypothesis is further informed by the association between openness/intellect and interest-appraisal relations. Appraisal theories of emotions contend that the way we feel is, in part, determined by the way we cognitively appraise situations (Ellsworth & Scherer, 2003). However, within-person emotion-appraisal relations differ between individuals, and such individual differences are meaningfully related to between-person constructs such as personality traits (see Kuppens & Tong, 2010 for a review). Going beyond single emotions, the implication of this is that the within-person relation between emotional states, and lack thereof, is determined by the level of shared or overlapping appraisals (Pe & Kuppens, 2012; Tong & Jia, 2017). Thus, individual differences in the tendency to differentiate emotions is associated with less appraisal overlap between emotions (Erbas, Ceulemans, Koval, &

Kuppens, 2015; Pe & Kuppens, 2012)—people who have lower within-person relations between emotions of the same valence also tend to have less appraisal overlap between these emotions.

Based on appraisal theory, interest and confusion should be reluctant bedfellows. They share the same two dimensional appraisal space, determined by complexity and comprehensibility. Both interest and confusion are positively associated with appraisals of complexity, but are differentiated by appraisals of comprehensibility—stimuli that are appraised as complex are experienced as interesting if they are comprehensible, but confusing if they are not comprehensible (Silvia, 2010). Thus, we predict that the states will have a negative relation. However, research into individual differences in appraisal-interest relations suggests that there are individual differences in experiencing distinct types of interest. For some, interest is primarily driven by the appraised complexity of the stimulus, and less so by comprehension appraisals, while for others interest is primarily driven by comprehension, and to a smaller extent by complexity (Silvia et al., 2009). The appraisal weights associated with the first type of interest—driven primarily by complexity—are conceptually closer to confusion, compared with the second type—comprehension driven.

As it happens, such differences in interest-appraisal relations are consistently associated with openness/intellect. In the original study to discover two clusters of interest, openness/intellect was associated with membership in the complexity cluster (Silvia et al., 2009). This finding has been replicated using multilevel analyses that model appraisal-interest relations continuously, with different models of openness/intellect, and in response to various stimuli (Fayn et al., 2015; Fayn et al., 2017; Fayn et al., 2015). Thus, open people are particularly differentiated from closed people in experiences of interest in complex and difficult to understand epistemic situations,[2] which should theoretically involve the experience of confusion. Therefore, we predict more positive interest-confusion relations for those higher in openness/intellect.

Lower Level Aspects of Openness/Intellect

The broad domain of openness/intellect can be divided into two related yet distinct aspects—openness and intellect (DeYoung, Quilty, & Peterson, 2007). The aspects are linked in terms of both describing individual differences in cognitive exploration, yet distinct, with openness describing exploration of sensory and perceptual information, while intellect describes exploratory tendencies in response to abstract and semantic information (DeYoung, 2015). From this perspective, it could be speculated that openness will be particularly relevant for interest-confusion relations in the aesthetic domain, and the influence of intellect would manifest in interest-confusion relations in response to semantic information. However, an alternative way to consider the distinction between openness and intellect is in terms of cognitive versus emotional engagement (Fayn et al., 2017). This cognitive affective distinction is informed by the previously discussed research on the moderating role of openness/intellect on interest-appraisal relations, where openness is the stronger predictor of the emotion of interest in response to aesthetic and semantic information, and the more consistent moderator of interest-appraisal relationships (Fayn, MacCann, et al., 2015; Fayn et al., 2017; Fayn, Tiliopoulos, et al., 2015). Rather than emotional engagement associated with openness, the role of intellect during cognitive engagement seems to be in greater cognitive resource allocation (Smillie, Varsavsky, Avery, & Perry, 2016). Thus, it is expected that the openness aspect of the broad domain will be particularly predictive of more positive interest-confusion relations.

The Current Research

The relation between interest and confusion has not, to our knowledge, been previously explored. We propose that while these states will be negatively related on average, this relation will vary as a function of individual differences aligning with the personality dimension of openness/intellect. Given the lack of previous research on the relation between interest and confusion, it is speculative to propose what individual differences in this relation might mean. Broadly speaking, novel and complex epistemic experiences, by definition, begin with confusion, or at least a lack of understanding, yet open people tend to engage with such experiences. For example open people are particularly interested in difficult to understand epistemic stimuli like abstract art, they tend to be high in investigative interests that involve trying to resolve confusion, they create new art and knowledge, and tend to spend more time engaged with learning. We propose that a person for whom interest and confusion have a positive relation, compared with a person for whom the states are negatively related, is more likely to persist through and even enjoy difficult epistemic situations—that could be a key feature of being open-minded. Thus, the interest-confusion dynamic we propose to be involved in openness/intellect, could help to explain some of the outcomes associated with openness/intellect.

We tested our hypothesis by making use of different paradigms, stimuli, statistical methods, and participants—students and Amazon Mechanical Turk (MTurk) workers. In Study 1, we examine the interest-confusion relation, and individual differences in the relation as a function of openness/intellect, in response to visual art in a lab. In Study 2, we investigate the same relations in response to scientific, philosophical, and visual art stimuli in a lab. In Study 3, we study the same relations in response to self-selected learning situations—psychology lectures. In Study 4, we experimentally manipulate confusion to test whether openness/intellect particularly predicts interest when confusion is elicited versus when it is not. Finally, in Study 5 we explore the interest-confusion relation over the course of a complex problem solving task—a microworld simulation. Some of the studies within this article made use of secondary data sets for this project that have previous publications associated with them—Studies 1 and 4 (Barford et al., 2018; Fayn, MacCann, et al., 2015; Fayn et al., 2018), and Study 2 (Fayn et al., 2017). The analyses presented within this article do not overlap with previous publications based on these data sets. Given that we used secondary data, the sample sizes for Studies 1, 2, and 4 were not determined by a priori power calculations. The observed power for the tests of the main hypothesis—correlation between openness/intellect and interest-confusion relations were 0.69 for Study 1, 0.79 for Study 2, and 0.67 for Study 4. The power analysis for Study 5 is based on the results of the preceding studies and is reported below. All data exclusions (in text below) and all measures and conditions are reported (supplementary materials S2).

[2] By epistemic situation we mean any situation—for example, an artwork or a scientific report—that has the potential to communicate knowledge though cognitive processing.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Analyses

We used SPSS 21 for all correlations, analysis of variances (ANOVAs), and descriptive statistics, and Mplus 7 for all the other analyses (Muthén & Muthén, 1998–2012). Our interest-confusion moderation hypotheses were tested in two ways. First, we calculated the interest-confusion correlations for each individual independently and then correlated this variable with between-person variables. Second, we tested our hypothesis via multilevel analyses using within-person standardized variables. This standardization was performed as it overcomes the issue of asymmetry in a multilevel context and, thus, makes the prediction of interest on confusion or confusion on interest produce identical results. Without this standardization, using multilevel modeling in this context is debatable, as the choice of which valence should be modeled as a predictor versus outcome is fairly arbitrary, and can severely impact the results, a point that is highlighted by Ong, Zautra, and Finan (2017). The use of multilevel modeling also allowed us to test the unique effects of multiple variables. For interpreting effect sizes, we use the Gignac and Szodorai (2016) guidelines of r = .10/0.20/0.30 as small/medium/large.

Research Ethics Approvals

The ethics committees at the universities of Sydney, North Carolina at Greensboro, and KU Leuven approved the study procedures. The Study 1 and 4 protocols were approved by Human Research Ethics Committee at the University of Sydney and by the Institutional Review Board at the University Of North Carolina At Greensboro under the title "Aesthetic Experiences Project," ethics reference number: 13–0033. The Study 2 and 3 protocols were approved by the Human Research Ethics Committee at the University of Sydney under the title "Individual differences in engagement with epistemic stimuli," ethics reference number: 2013/325, and "Personality processes that lead to epistemic engagement and academic achievement," ethics reference number: 2014/197. The Study 5 protocol was approved by the Social and Societal Ethics Committee under the title "The influence of cognitive-affective states on learning," ethics reference number: G-2018 03 1172.

Study 1

In this first study, we examined the relation between openness/intellect and the within-person interest-confusion relation in response to visual art stimuli of different styles, periods, and themes (see online supplementary materials from Fayn et al., 2018 for a list of artworks). We predicted a negative relation between interest and confusion overall, and that openness/intellect would predict more positive interest-confusion relations.

Method

Participants. Participants (n = 225) from various degrees took part in the study for course credit. The sample was predominantly female (69%) with a mean age of 20.56 years (SD = 4.91).

Procedure. Data were collected from groups of up to 10 participants. Participants initially filled in some individual differences assessments, followed by viewing and rating 18 visual art stimuli presented in a random order for each participant, followed by more individual differences assessments. Participants viewed each image on computer screens for as long as they wanted with a minimum of 5 s. Next, they answered questions while a smaller version of the image was present on the screen, without the possibility of going back to view the full sized stimulus. Participants were told to report on their thoughts and feelings in response to each image, and that we were interested in their personal reactions, rather than how they think others might react.

Measures.

Big Five Personality. Participants completed the NEO Five Factor Inventory (Costa & McCrae, 1992) by rating 60 items (12 for each domain) on a 5-point Likert scale from *strongly agree* to *strongly disagree*. Because of time constraints, only 221 participants completed the full instrument. The scales for each domain demonstrated acceptable internal consistency (Cronbach's αs ranged from .77 to .83). The openness/intellect domain was further assessed using the Big Five Aspects Scales (BFAS) that divides each personality domain into two aspects (DeYoung et al., 2007). Only the two aspects of the openness/intellect domain—openness and intellect—were assessed. The scale consists of 20 items (10 per aspect) on a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). The Cronbach's αs for the full scale (.83), openness (.82), and intellect (.79) scales were acceptable.

Interest and confusion. Participants reported their interest, confusion in response to each stimulus. Interest and confusion were measured via 7-point Likert type scales (1 = *not at all*, 7 = *very much*). Participants also rated the images on other emotions that are not relevant to the current investigation, but are listed in the supplementary materials (S2).

Data cleaning. The validity of responses where participants provided multiple answers at the same point on the scale is questionable. Thus, we deleted "straightlining" responses—invariant across the different questions asked for each stimuli/situation (McCabe, Mack, & Fleeson, 2012). From a total of 4,068 ratings of images, 71 responses were invariant (2% of total) and, therefore, removed from final analyses.

Results and Discussion

Descriptive statistics and correlations between openness/intellect measures, and interest-confusion relations are reported in Table 1. Contrary to our prediction, the average within-person correlation was around zero (see Table 1), but as predicted, this estimate varied substantially between people (see Figure 1). As predicted, openness/intellect was associated with variance in interest-confusion relations—the relation was more positive for people higher in openness/intellect. These relations were particularly apparent for both domain level assessments of openness/intellect, and the openness, but not intellect, aspects of the BFAS scale (see Table 1). The effect size for the significant relations is small to medium. A multilevel model was used to test the unique influence of openness and intellect by modeling their influence concurrently. The model reproduced the correlational results—openness was significantly related to more positive interest-confusion relations, whereas intellect was not (see Table 2). The effect of openness/intellect remained significant when controlling for the other personality domains, while extraversion predicted more negative interest-confusion relations (S1, Table S2). Because of a lack of hypotheses regarding the other Big Five domains, and no consistency in associations with the other domains across studies, we refrain

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Table 1
Study 1 Descriptives and Pearson's Correlations Between Openness Measures and Within-Person Interest-Confusion Relations

Measures	Mean	*SD*	BFAS O	BFAS I	NEO O	Interest-confusion
BFAS openness/intellect	3.77	.46	.84**	.83**	.76**	.15*
BFAS openness	3.92	.56		.39**	.75**	.16*
BFAS intellect	3.62	.55			.53**	.09
NEO openness	3.84	.69				.15*
Interest/confusion	.02	.31				

Note. BFAS = Big Five Aspects Scales; OI = openness/intellect. Sample for NEO correlations is 221, compared with 225 for the rest.
* $p < .05$. ** $p < .01$.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

from discussing them, but report bivariate and multilevel associations in the supplementary materials (S1).

In summary, these findings suggest that, in the context of visual art, interest, and confusion are, on average, statistically independent from each other, but also that this relation varies significantly between people. Part of this variance is associated with openness/intellect—more positive interest-confusion relations in those higher in openness. As predicted, the significant relation between interest-confusion relations and openness, as opposed to intellect, is supported by previous interest-appraisal relation findings (Fayn, MacCann, et al., 2015; Fayn et al., 2017; Fayn, Tiliopoulos, et al., 2015), but may also have resulted because of the artistic nature of the stimuli. Openness is particularly related to engagement with the arts and to individual differences in interest-appraisal relations in the context of visual art (Fayn et al., 2017). Given the appraisal space of interest and confusion, it was surprising that the relation between interest and confusion was close to zero for the whole sample. This may be because of the artistic nature of the stimuli for which interest and confusion may be statistically independent on average. Given these limitations, Study 2 aimed at replicating the findings from Study 1 with a larger and broader range of stimuli.

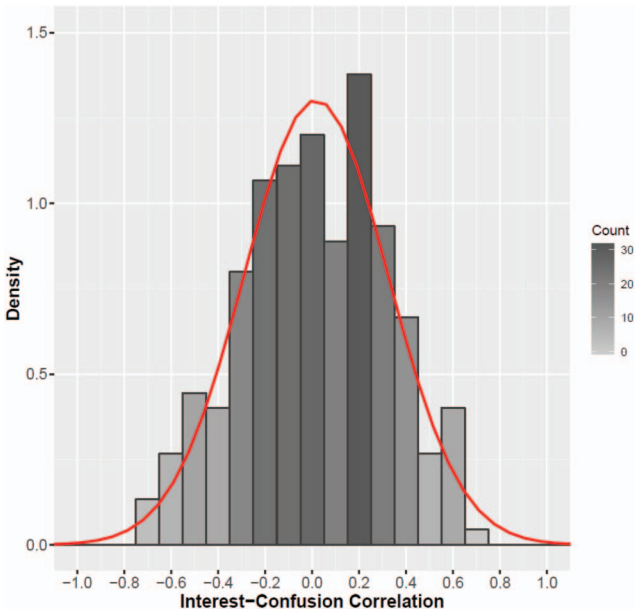

Figure 1. Density and frequency distribution of participants' interest-confusion correlation, with inferred normal distribution. See the online article for the color version of this figure.

Study 2

In this study, we evaluated the internal interest-confusion relation for a broader set of stimuli, which included popular scientific news stories, philosophical quotations, and visual artworks (for a full set of stimuli see online supplementary materials from Fayn et al., 2017). We also used a broader measure of openness/intellect that divides the domain into six facets (Woo et al., 2014). We predicted a negative relation between interest and confusion overall, and that openness/intellect would predict more positive interest-confusion relations. Further, we sought to replicate the near zero interest-confusion relation for artworks found in Study 1, but expected the relation to be negative for science and philosophy stimuli.

Method

Participants. Participants (n = 191) from various degrees took part in the study for credit. The sample was predominantly female (77%) with a mean age of 19.27 years (SD = 3.70). Nine people were excluded from the final sample based on experimenter notes that indicated that the subject appeared not to take the study seriously, leaving a final sample of 182 participants.

Procedure. Data were collected from groups of up to 10 participants in a laboratory setting. Participants initially filled in individual differences assessments, followed by viewing and rating 30 stimuli presented in a random order for each participant. The stimuli consisted of 10 philosophical quotations, 10 science stories from Slashdot.com, and 10 visual art images. For further details on the stimuli see online supplementary materials from Fayn et al. (2017). As in Study 1, participants were asked to report on their feelings and thoughts in response to each stimulus. The stimuli were presented in a randomized order. Participants could view the stimulus for as long as they wanted but for a minimum of five (art, philosophy), and 10 (science) seconds. A smaller version of the image and philosophical quotation were visible during questionnaire, as was the title of the scientific story.

Measures.

Big Five Personality. Personality was assessed using the BFAS, which divides each personality domain into two aspects (DeYoung et al., 2007)—openness and intellect for the openness/intellect domain. The scale consists of 100 items (10 per aspect) on a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). The Cronbach's

Table 2
Multilevel Modelling Results Evaluating the Relationships Between Personality Measures and Interest-Confusion Slopes

	Study 1			Study 2			Study 3			Study 5		
Within person relationship	Estimate	*SE*	*p*-value	Estimate	*SE*	*p*-value	Estimate	*SE*	*p*-value	Estimate	*SE*	*p*-value
Interest-confusion	.02	.02	.36	−.22	.02	<.001*	−.17	.05	.001*	−.06	.03	.06
Between person moderation												
NEO openness/intellect	.04	.02	.03*									
BFAS openness/intellect	.05	.02	.02*	.04	.02	.02*	.12	.04	.002*			
Openness	.04	.02	.03*	.06	.02	.01*	.05	.04	.27			
Intellect	.01	.02	.62	−.01	.02	.67	.12	.04	.002*			
Intellect (Mussel)							.06	.04	.12	.07	.03	.049*
Seek							.02	.06	.76	.05	.07	.40
Conquer							.05	.05	.38	.02	.06	.80
BFI-2 openness/intellect										.09	.03	.003*
Intellectual curiosity										.06	.04	.11
Aesthetic sensitivity										.06	.04	.09
NFC										.03	.04	.47
BFI-2 openness/intellect										.07	.04	.07
ICAR										.04	.04	.25

Note. BFAS = Big Five Aspects Scales; OI = openness/intellect; NFC = Need for Cognition; BFI-2 = Big Five Inventory−2; ICAR = International Cognitive Ability Resource. Level 1 variables are within-person standardized.
* $p < .05$.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

αs for the full (.86), openness (.82) and intellect (.79) scales were acceptable. Internal consistencies were acceptable for the rest of the BFAS aspects, Cronbach's αs ranged from .73 to .89. Further, we assessed lower order facets of openness/intellect with a short-version of a recently developed measure that divides the domain into six facets (Woo et al., 2014)—depth, tolerance, aesthetics, curiosity, ingenuity, and intellectual efficiency. The scale consists of 54 items (9 per facet) on a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). Because of a computer coding error, data for one item of the depth facet was not recorded. The internal consistencies for the depth (.76), tolerance (.70), aesthetics (.90), ingenuity (.80), and intellectual efficiency (.84) facets were all acceptable. The internal consistency of the curiosity scale (.60) was slightly lower than desirable.

Interest and confusion. Interest and confusion were measured exactly the same way as in Study 1. Full information on the other measures in this study is available in the supplementary materials (S2).

Data cleaning. Straightlining responses were removed according to the same procedure as Study 1. From a total of 5460 ratings of stimuli, 88 responses were invariant (2% of total) and, therefore, removed from final analyses.

Results and Discussion

Descriptive statistics and correlations between openness/intellect measures and interest-confusion relations are reported in Table 3. This time, as predicted, interest and confusion were negatively related ($r = -.21$) on average, and this relation was substantially variable between people ($SD = .26$; Figure 2). The effect size for this relation is medium. From the BFAS, again the domain and openness, but not intellect, was associated with more positive interest-confusion correlations, with a medium effect size for openness, and a small to medium effect size for the domain. In the six-facet model of openness/intellect, the total score and all facets apart from ingenuity and intellectual efficiency were associated with more positive interest-confusion correlations. The effect size for the domain level openness/intellect was medium to large, and medium for the facets. The lack of significant relations with the ingenuity and intellectual efficiency facets of the openness/intellect domain are consistent with the lack of association with intellect here and in Study 1, as both facets load onto the higher order intellect aspect (Woo et al., 2014). Multilevel models were in line with correlation findings (see Table 2), openness, but not intellect was associated with the interest-confusion slope. Once again, the association with openness/intellect remained significant when controlling for the other domains. This time conscientiousness was associated with more negative interest-confusion relations (S1, Table S4). The effect of openness remained significant when controlling for the other aspects, with politeness and volatility predicting more negative interest-confusion relations (S1, Table S5). When the Woo et al., measure facets were modeled concurrently, none of the facets were significantly related to the slope, but the overall scale was, ($b = 0.06$, $SE = 0.02$, $p = .001$).

Given our speculation from Study 1—that on average interest-confusion relations were close to zero because of the artistic nature of our stimuli—we tested this possibility by comparing the

Table 3
Study 2 Descriptives and Pearson's Correlations Between Openness Measures and Within-Person Interest-Confusion Relations

Measures	Mean	*SD*	O6T	O6D	O6A	O6C	O6I	O6IE	OI	Openness	Intellect	Interest-confusion
O6 total	3.61	.42	.69**	.74**	.84**	.72**	.73**	.55**	.81**	.76**	.62**	.25**
O6 tolerance	3.88	.55		.57**	.55**	.40**	.31**	.14	.37**	.42**	.20**	.16*
O6 depth	3.85	.56			.63**	.38**	.37**	.18*	.57**	.63**	.33**	.22**
O6 aesthetics	3.64	.79				.49**	.52**	.25**	.68**	.78**	.36**	.23**
O6 curiosity	3.84	.44					.53**	.41**	.57**	.48**	.50**	.20**
O6 ingenuity	3.42	.59						.41**	.62**	.53**	.53**	.14
O6 intellectual efficiency	3.05	.60							.62**	.32**	.77**	.10
BFAS openness/intellect	3.63	.50								.88**	.84**	.16*
BFAS openness	3.78	.62									.48**	.20**
BFAS intellect	3.47	.54										.07
Interest-confusion	−.22	.26										

Note. BFAS = Big Five Aspects Scales. O6 refers to the Woo et al. (2014) measure of openness; OI refers to BFAS openness/intellect scale.
* $p < .05$. ** $p < .01$.

interest-confusion relations between the three sets of stimuli. We expected that interest-confusion relations would be smaller for philosophy and science stimuli when compared with visual art stimuli. A repeated measures ANOVA revealed overall differences in interest-confusion relations between the difference stimuli, $F(2, 352) = 12.65$, $p < .001$. As expected, interest-confusion relations for art stimuli ($M = 0.08$, $SD = .38$) were significantly weaker when compared with science ($M = 0.27$, $SD = 0.40$) and philosophy ($M = 0.23$, $SD = 0.38$) stimuli, $F(1, 176) = 22.60$, $p < .001$, $\eta_p^2 = .114$, and did not differ between science and philosophy stimuli, $F(1, 176) = 1.18$, $p = .279$, $\eta_p^2 = .007$. This finding suggests that the average interest-confusion relation varies according to the type of eliciting information.

In summary, Study 2 confirmed our hypothesis that interest and confusion are negatively related states—apart from the context of visual art—yet a considerable amount of variability can be observed in this relation. Similar to Study 1, both domain level measures, openness/intellect and its facets, as opposed to intellect and its facets, were associated with more positive interest-confusion relations. This is consistent with previous findings regarding interest-appraisal differences (Fayn, MacCann, et al., 2015; Fayn et al., 2017; Fayn, Tiliopoulos, et al., 2015), and more broadly supports the idea that the distinction between openness and intellect may be a distinction of emotional versus cognitive engagement with information (Fayn et al., 2017).

Whereas the previous studies used stimuli that were selected by the experimenters, Study 3 extends the test of our hypothesis into a personally relevant domain with self-selected learning situations—university lectures.

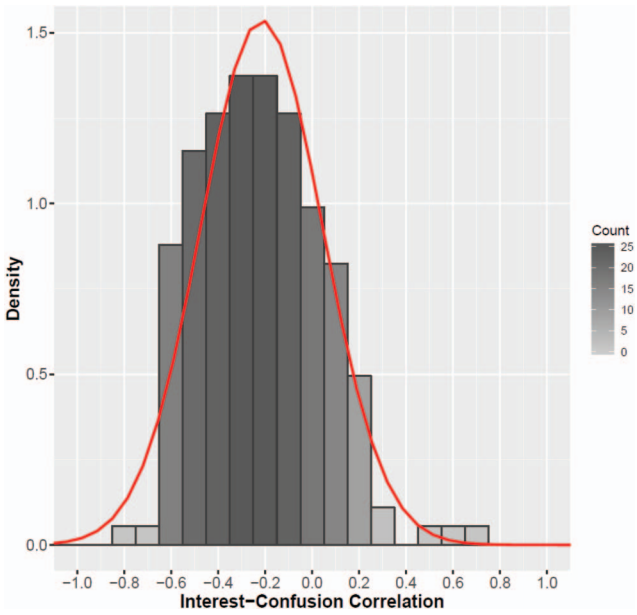

Figure 2. Density and frequency distribution of participants' interest-confusion correlation, with inferred normal distribution. See the online article for the color version of this figure.

Study 3

In Study 3, individual differences in interest-confusion relations were evaluated in response to first year psychology lectures. Students were chosen from a first-year psychology course and rated their normal lectures on emotions and appraisals. In addition to the previously used BFAS openness/intellect scales, a broader intellect measure was used in this study (Mussel, 2013). Given that intellect measures have been shown to be particularly relevant in learning contexts (Von Stumm & Ackerman, 2013), we sought to investigate the differential roles that distinct facets of intellect may play in interest-confusion relations. We predicted a negative relation between interest and confusion overall, and that openness/intellect would predict more positive interest-confusion relations.

Method

Participants. The sample consisted of 95 students enrolled in a first year psychology course. Participants took part in the study for course credit, which involved rating 12 psychology lectures on interest, confusion, and other variables not relevant to this article. Because of a computer malfunction personality scores were lost for four participants. Further, we excluded participants that failed to report on at least half of the lectures (compliance <50%). This left a final sample of 72 participants (77% female) with a mean age of 19.71 years ($SD = 6.68$). From a total of 697 ratings of lectures,

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

five responses were invariant (less than 1% of total) and, therefore, removed from final analyses.

Procedure. During an initial laboratory session, participants (groups of up to nine people) completed a battery of personality assessments. Over the course of the next 6 weeks, participants filled out an online questionnaire for two lectures a week. Participants were reminded via e-mail before and after class to fill in the questionnaire. Participants who listened to the lectures online instead of attending were told to fill in the questionnaire after listening to the lectures.

Measures.

Personality measures. The measures for, BFAS personality, interest and confusion were identical to those described in Study 1. The internal consistencies for BFAS openness/intellect (.73), openness (.70), and intellect (.80) were acceptable. In addition to these measures, participants also completed Mussel's (2013) intellect scale. The scale measures several facets of the intellect aspect of the openness/intellect domain, and which divide into two processes, and three operations. The two processes—seek and conquer—reflect two motivational orientations. Seek refers to the motivational tendency to approach situations that are intellectually challenging, whereas conquer refers to motivational tendencies associated with the effort and persistence once such situations are encountered. The three operations—think, learn, and create—are proposed to be preferences based on distinctions between fluid intelligence, crystallized intelligence and creativity. The scale includes 24 items rated on a 7-point Likert scale from *strongly disagree* to *strongly agree*. Internal consistencies for Conquer (.92), Seek (.91), Think (.89), Create (.86), and Learn (.86) were all acceptable.

Interest and confusion. Interest and confusion were measured exactly the same way as in Study 1. Full information on the other measures in this study is available in the supplementary materials (S2).

Results and Discussion

The descriptive statistics and correlations between the study variables are presented in Table 4. Once again, interest and confusion were negatively correlated on average ($r = -.16$), yet this relation varied substantially between people ($SD = .46$; Figure 3).

Replicating the findings from Studies 1 and 2, openness/intellect was significantly related to more positive interest-confusion relations. This time, apart from the BFAS domain scale, it was the intellect aspect that was associated with more positive interest-confusion relations. The effect size for these relations was medium to large. Multilevel models produced concordant results—intellect, but not openness, significantly predicted the interest-confusion slope (see Table 2). The effect of openness/intellect remained significant when controlling for the other domains and conscientiousness also predicted more positive interest confusion relations (S1, Table S7). Within the faceted intellect measure, the think facet trended toward significantly predicting more positive interest-confusion relations ($p = .055$), and was significantly related to the interest-confusion slope using multilevel modeling, ($b = 0.10$, $SE = 0.04$, $p = .01$). The effect size for this relation was medium. The think facet reflects individual differences in engagement with and appreciation of thinking through complex theories and problems, which could render confusing situations into interesting

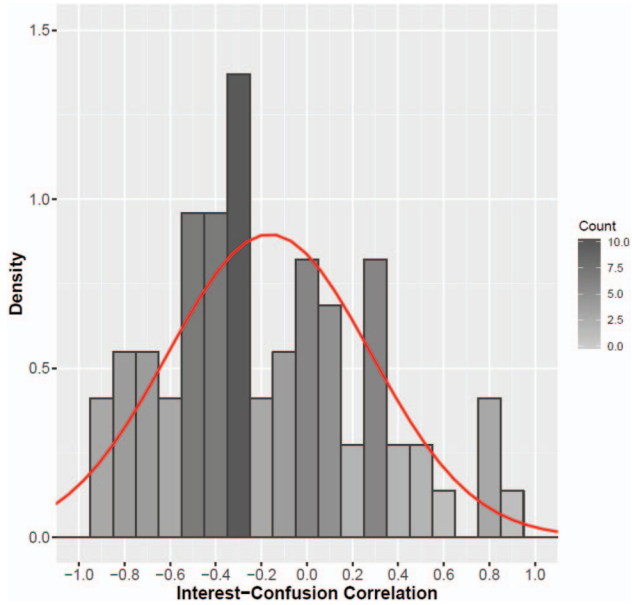

Figure 3. Density and frequency distribution of participants' interest-confusion correlation, with inferred normal distribution. See the online article for the color version of this figure.

Table 4
Study 3 Descriptives and Pearson's Correlations Between Openness Measures and Within-Person Interest-Confusion Relations

Measures	Mean	*SD*	Open	Intellect	Seek	Conquer	Think	Learn	Create	Interest-confusion
Openness/intellect	3.49	.39	.70**	.74**	.49**	.32**	.47**	.32**	.40**	.27*
Openness	3.55	.53		.04	.16	.13	.14	.12	.18	.12
Intellect	3.42	.56			.53**	.32**	.53**	.33**	.38**	.27*
Seek	4.97	.92				.61**	.79**	.79**	.82**	.09
Conquer	4.47	.98					.86**	.85**	.71**	.11
Think	4.65	1.06						.77**	.65**	.22
Learn	4.87	.95							.69**	.07
Create	4.65	.85								.03
Interest-confusion	−.16	.45								

Note. ICAR = International Cognitive Ability Resource.
* $p < .05$. ** $p < .01$.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

ones; therefore, predicting greater interest confusion independence.

Based on the recommendation of a reviewer and the editor, we ran a post hoc test to investigate whether using seek and conquer as concurrent predictors of the interest-confusion relation may bring forth a suppressor effect. It was predicted that seek—given its conceptualization as seeking all kinds of new information—would be related to more positive interest-confusion relations, particularly when you partial out the effect of conquer—given its conceptualization as a motivation to master new information, rather than simply enjoying it. Entering seek and conquer into the between-person level of the multilevel model did not support this hypothesis—neither measure was significantly associated with the interest-confusion slope (see Table 2). However, this study is somewhat underpowered and, therefore, we investigated this hypothesis further in Study 5.

In summary, Study 3 mostly replicated the finding that the openness/intellect domain is associated with more positive interest-confusion relations. However, the intellect aspect, not the openness aspect, was the significant predictor of more positive interest-confusion relations. This finding supports the distinction between openness and intellect, where intellect thought to represent engagement in abstract and semantic content (DeYoung, 2015), such as the scholarly content in psychology lectures. Thus, the results are largely consistent with those observed in Studies 1 and 2. Studies 1–3 tell a consistent story of how the openness/intellect domain manifests in terms of interest-confusion relations. In Study 4, we tested this relation experimentally.

Study 4

Having replicated the relation between openness/intellect and the interest-confusion relation in Studies 2 and 3, we sought to test our theory experimentally. If the relation between interest and confusion varies as a function of openness/intellect, open people may be less affected, in terms of their interest, by a confusion manipulation. We tested this hypothesis by manipulating confusion and testing the effects this manipulation had on interest, and whether the manipulation effect was moderated by openness/intellect. The manipulation was rather simple—participants read a poem with or without an explicit explanation regarding the subject of the poem. This manipulation has previously been shown to alter the appraised comprehensibility of the poem (Silvia, 2005), and the same manipulation with a different poem has been shown to affect confusion (Silvia, 2010). Thus, the manipulation should affect ratings of confusion, and based on our findings in Studies 1–3, we predicted that openness/intellect would interact with the manipulation in such a way that openness/intellect would be a stronger predictor of interest in the confusing condition compared with the nonconfusing condition.

Method

Participants. The data used for this study is the same as Study 1. Students from various majors ($n = 225$) participated in the experiment for either course credit or $10 USD. Six participants were excluded because of invariant responding. A further five participants were excluded because they did not finish the personality assessment because of a lack of time. The final sample, therefore, included 214 participants (69% female) with a mean age of 20.25 years ($SD = 3.92$).

Procedure. Participants completed the study in small groups where they were told that the study is about the relation between personality and aesthetic emotions. Participants initially filled out some individual difference questionnaires and then viewed and rated various artworks. Participants were then randomly assigned to one of two conditions that involved reading and rating a poem with or without explanation. After reading the poem participants filled out the personality assessment used in the current analyses. The poem appeared in a book called *The Life of Haifisch*, written by Scott MacLeod (1999). Participants in the information condition received the following instructions:

> The following page has a poem by Scott MacLeod. Please read it, see how you feel about it, and then give your impressions and reactions on the following pages. This poem is titled The Whitest Parts of the Body, and it's from his book *The Life of Haifisch*. ("Haifisch" means "shark" in German. All of the poems in this book, including the poem that you will read, are about killer sharks).

Participants in the no information condition did not get to see the final two sentences from the instructions above.

After reading the poem participants rated the poem on interest, confusion, as well as other emotions and appraisals—see supplementary materials (S2). The interest and confusion items were the same as in the previous two studies.

Measures.

Big Five Personality. The personality measures and reliabilities are exactly the same as in Study 1—NEO Five Factor Inventory (Costa & McCrae, 1992) and BFAS openness/intellect scale.

Interest and confusion. Participants reported on their interest and confusion (1 = *not at all*, 7 = *very much*) in response to each stimulus.

Results and Discussion

First, we tested whether the random allocation happened to create groups that differed from each other in terms of personality. We observed that the groups did not differ from each other on any of the big five domains, *p*s ranged from .201 to .992. Next, we tested whether the manipulation affected confusion. As expected, people in the no-information condition reported higher levels of confusion, $t(214) = 2.34$, $p = .02$, $\eta_p^2 = .025$, but no differences in interest were observed, $t(214) = 0.05$, $p = .96$, $\eta_p^2 < .001$.

A moderated regression was used to test whether openness/intellect moderated the effect of the manipulation on interest in the poem. Contrary to prediction, openness/intellect did not moderate the effect of the manipulation on interest—nether the NEO measure, $b = -0.001$, $t = 0.02$, $p = .997$, nor openness, $b = 0.007$, $t = 0.08$, $p = .94$, nor intellect, $b = -.003$, $t = 0.09$, $p = .73$. Thus, this study failed to confirm our hypothesis. There are some issues with the study that could have contributed to this failure. First, while the manipulation of confusion is statistically significant, the means for the two conditions (4.68 and 4.12, on a 7-point scale) may not have been practically significant—both are around the middle of the scale of the confusion—and the effect size of this difference is small. Second, while the first two studies focused on individual differences in the within-person interest-confusion relations, this study only had one stimulus. Two conclusions are

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

possible from this study—the confusion manipulation was not strong enough to confirm our hypothesis, or that our previous findings do not extent to between-person differences in interest and confusion elicited in a single moment. Therefore, we conducted another study that sought to manipulate confusion over the course of a complex problem solving task.

Study 5

We used a complex problem solving task that got progressively more challenging—and, therefore, confusing—to test our main hypothesis. For this, we adapted a previously developed microworld simulation task used to investigate complex learning and decision making (Birney, Beckmann, Beckmann, Double, & Whittingham, 2018). We chose this task for several reasons. First, the task has several levels of complexity that go from straightforward to arguably almost impossible—allowing us to use conditions that should elicit different levels of confusion. Second, it is a dynamic and intrinsically motivating task that involves complex problem solving and learning; thus, fitting within our category of an epistemic situation. Third, it is a task where interest and confusion can be measured over time, and should vary as a function of time and complexity, allowing us to directly test the relation between these states (in contrast to what was possible in Study 4).

We adapted the task to include several conditions from simple to very difficult within one simulation. The goal of this adaptation was to manipulate confusion in a progressive way—from clear to very confusing. Given our results from Study 3—intellect emerging as the strongest predictor of interest-confusion relations—we expected that intellect would also be the stronger predictor within this task. To cover the intellect domain broadly we included Mussel's (2013) intellect scale, and the need for cognition scale (Cacioppo, Petty, & Kao, 1984). Further, we used another recently developed Big Five measure, and also included an intelligence measure to exclude the possible influence of ability on interest-confusion relation variability. We preregistered the study (https://aspredicted.org/8ya2s.pdf) with the following hypotheses:

> *Hypothesis 1 (H1):* Openness/intellect will be associated with a more positive correlation between interest and confusion during the microworld task. The intellect based scales are expected to be stronger predictors compared with openness based scales.
>
> *Hypothesis 2 (H2):* Seek, rather than conquer (facets of Intellect), will be associated with a more positive correlation between interest and confusion during the microworld task.[3]

Method

Participants. The sample consisted of MTurk participants (n = 252) who reported living in the United States, who had completed at least 100 approved studies with at least a 95% approval rating. Participants had an average age of 33.35 years (SD = 9.04). The participants completed the survey and task online and were paid $10 US for approximately one hour of their time. Six participants were excluded for attempting the first part of the study multiple times, after having failed two out of three attention checks or having failed a test based on the comprehension of the instructions presented at the end of the first part of the study. As outlined in our preregistration and in line our previous studies, a further 85 participants were excluded from the analysis because of invariant responding, leaving a final sample of 161 participants. While this is a relatively large number of excluded participants, it should be considered in the current context of well publicized issues with MTurk samples (e.g., Bai, 2018, August 8), which have now been acknowledged by MTurk (TurkPrime, 2018, September 18).

Procedure. Participants initially read a consent form and after agreeing to participate completed a battery of personality tests, followed by detailed instructions for the microworld simulation. This was followed by a three question test that evaluated whether the participants read the instructions properly. Participants who failed to answer any of the three questions correctly were instructed to read the instructions again—they had three chances to get all three questions right. After the successful completion of the test, participants went through a simple practice trial of the microworld simulation. Halfway through the trial the participants were told the rule required to successfully interact with the microworld, and then completed the second half of the practice trial. The experimental task followed the practice, followed by some emotion ratings, another personality measure, and an intelligence test. Participants were debriefed, given a code to enter into the MTurk system to ensure payment and thanked for their time.

The mircoworld task. The microworld simulation was based on a previously used task (Birney et al., 2018). The original task was designed for middle management participants and the goal of the task was to manage staff levels of a company. To make the task more engaging to the general population we adjusted the focus by making ecosystem management the cover story of the task. During the task, participants were put in charge of keeping the population of species on an island at a certain level. The only way they could affect the ecosystem was to introduce species to the island or relocate species from the island. Participants were told that for the ecosystem to function optimally, the population had to be kept at 100 species. The participants were also told that the ecosystem was not stable, and that the way it behaved could change over the course of the experiment. As in the original task, the system could vary in two ways—in the natural extinction of species (every simulation leads to some animals going extinct—outflow), and in the time that participant based manipulations would affect the system (delay—e.g., a delay of zero indicates that the participant's decision would affect the system the next trial, whereas a delay of two would offset the decision by two trials). Utilizing the findings from Birney et al. (2018), we selected several conditions—that differed in terms of delay and outflow—based on the performance of the managerial sample. Unlike the original study—which had eight different variants of microworlds that the participants were instructed to interact with separately—in our experiment participants completed one long trial where the conditions changed without any notice that the system has changed.

[3] The wording of the hypotheses in the preregistration is slightly different to what is stated here. The preregistration predicted 'higher' as opposed to 'more positive' relations. The differences resulted from the review process when we were encouraged to change the wording to make the hypotheses clearer.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

During the microworld simulation participants could monitor their progress in several ways. Two dynamic feedback graphs were presented—the introduction and reallocation decisions made at each trial, and the amount of species on the island at each trial. Additionally, participants were given feedback based on each trial—the number of species the island was above and below the target, and by how many species they were closer to the target compared with the previous trial. In the original use of this task, participants were presented with an additional graph—instead of this more detailed feedback—that plotted their accumulative penalty—the sum of the difference between the goal and the actual performance (see Figure 4 for a screenshot of the task). We adjusted this feedback for two reasons. First, during piloting it appeared that participants were not adjusting very well based on their performance and, thus, we sought to make it less cognitively challenging to determine performance on a trial by trial basis. Second, because of the added length—compared with Birney et al. (2018)—and complexity changes during the simulation, the scale of the cumulative penalty graph would be too large to notice subtle differences in performance. A screenshot from the task is presented in Figure 5.

Altogether there were 61 trials with interest and confusion ratings being collected every third trial—totaling 20 reports. Originally we intended to measure interest and confusion each time point, but pilot participants found this quite annoying and disturbing to their experiences with the task. The first 11 trials had a constant outflow (extinction rate) of 10 species per trial. The first manipulation designed to affect confusion came at Trial 6—a mass extinction event that eliminated 50 species from the population. From Trial 12 to 23 the outflow changed from 10 to 20 species per trial. From Trial 24 to Trial 42 the outflow became varied—ranging from 10–30—with an approximate average of 20 per trial. At Trial 42, there was another mass extinction event—a reduction of 50 species from the population. From Trial 42 till Trial 61 the effect of participant decisions was delayed by two trials. The mass extinction event coincided with the change in the delay parameter because without an adjustment to participant behavior on this trial, it would be very difficult to know that the delay has changed. For example, if a participant had worked out that the best course of action during the random outflow trials is to add 20 species at each simulation, no change in outflow would result in good performance. If on the other hand, they had to adjust to a mass extinction event, this change would only take place two simulations later. All

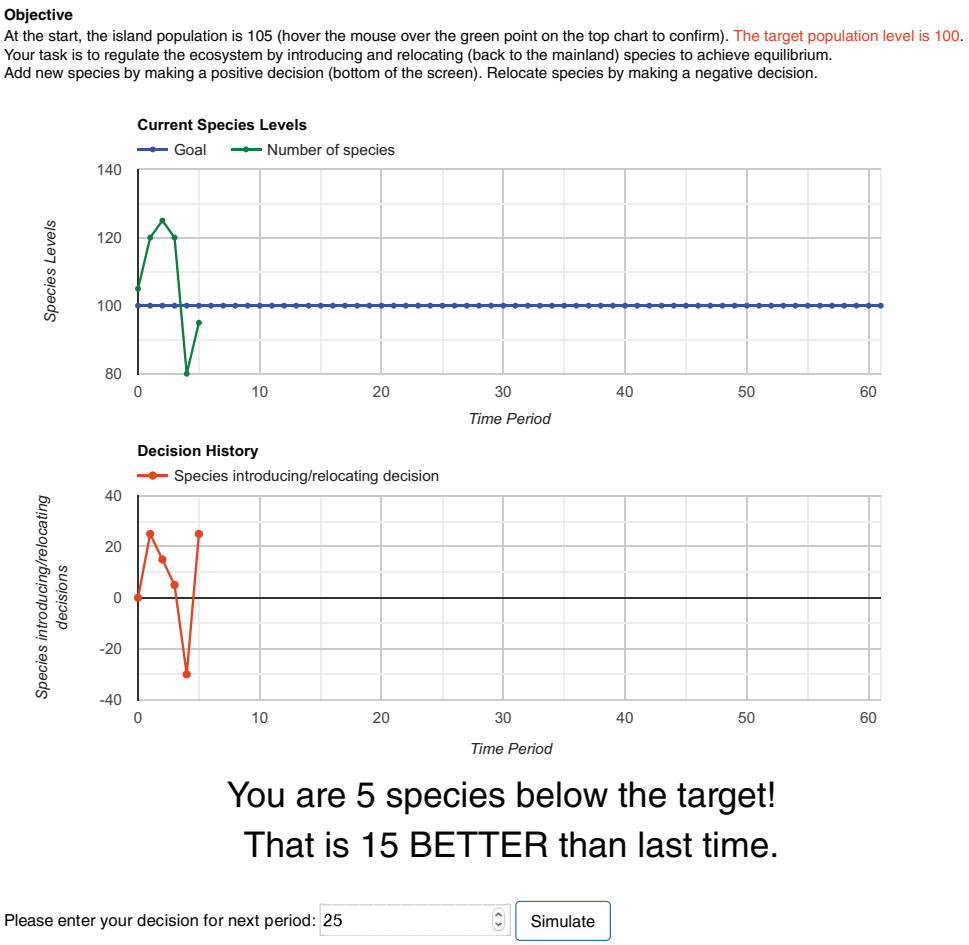

Figure 4. Screenshot of the microworld task. See the online article for the color version of this figure.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

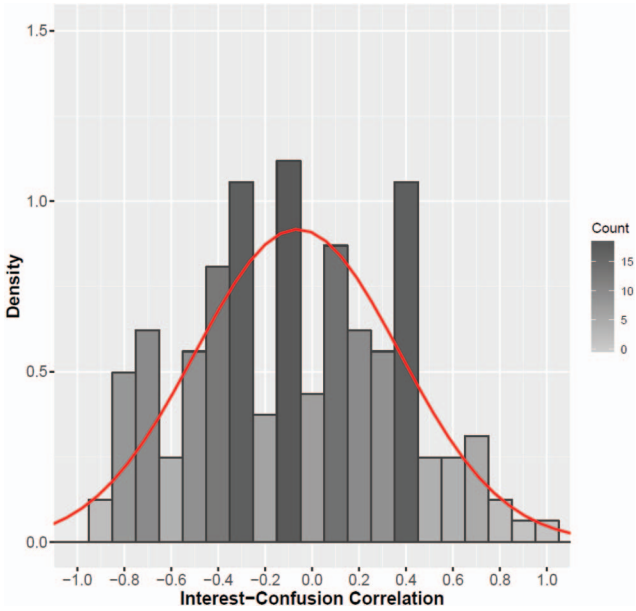

Figure 5. Density and frequency distribution of participants' interest-confusion correlation, with inferred normal distribution (Study 5). See the online article for the color version of this figure.

these changes to the system represent gradual changes in the complexity of the task and were, therefore, predicted to increase the confusion experienced by participants.

Measures.

Personality and intelligence. The Big Five Inventory−2 (BFI-2; Soto & John, 2017) was administered. The 60-item BFI-2 measures five domains of personality with three facets each—intellectual curiosity, aesthetic sensitivity, and creative imagination for openness. Each item is rated on a 5-point Likert scale from *strongly agree* to *strongly disagree*. The scales for each domain demonstrated high internal consistency (Cronbach's αs ranged from .87 to .94). The scales for each facet demonstrated acceptable internal consistency (Cronbach's αs ranged from .75 to .91). Cronbach's αs for the openness/intellect facets were .84 for intellectual curiosity, .87 for aesthetic sensitivity, and .83 for creative imagination.

Participants also completed two scales measuring the intellect aspect of the openness/intellect domain. As in Study 3, Mussel's intellect scale was administered. The internal consistencies of the scales were all excellent (.98 for the full scale and .93 to .96 for the subscales). Need for Cognition (NFC; Cacioppo et al., 1984) was assessed via 18 items using a 5-point scale from *extremely uncharacteristic of me* to *extremely characteristic of me*. The internal consistency of the scale was excellent (Cronbach's α of .96).

To assess intelligence the International Cognitive Ability Resource (ICAR) 16-item sample test was utilized (Condon & Revelle, 2014). The ICAR has been validated on five groups totaling 97,000 participants and includes items (four each) that assess verbal reasoning, letter and number series, matrix reasoning, and mental rotation. The internal consistency of the test was acceptable (Cronbach's α of .80).

Interest and confusion. Participants reported their interest and confusion every third trial of the microworld simulation (20 times overall). Both emotions were measured via a 7-point scale (0 = *not at all* to 6 = *very much*) by asking participants: "With regards to the state of the system right now, are you interested/confused?" Participants also rated two other emotions not relevant to the current investigation (see supplementary materials S2; Figure 4).

Results and Discussion

We first tested whether the designed microworld simulation worked in terms of manipulating confusion. It was expected that confusion would increase particularly at time points where task conditions changed. These predictions were tested via repeated measures ANOVAs. The effect sizes for the repeated measures ANOVAs were calculated with an adjustment for the correlations between the conditions as suggested by Morris and DeShon, (2002). Repeated measures ANOVAs revealed significant changes to confusion for four out of five manipulations to the task. Confusion significantly increased as a result of the mass extinction manipulation, $F(1, 160) = 116.10$, $p < .001$, $d = 0.84$, the transition between constant versus variable outflow, $F(1, 160) = 14.34$, $p < .001$, $d = 0.31$, the second mass extinction event, $F(1, 160) = 40.95$, $p < .001$, $d = 0.51$, and the introduction of a delay, $F(1, 160) = 13.18$, $p < .001$, $d = 0.29$. Confusion did not significantly change because of the change in outflow from 10 to 20 species per trial, $F(1, 160) = 2.73$, $p = .1$, $d = 0.14$. More important, neither openness/intellect, Mussel's intellect, or need for cognition interacted with the effects of the manipulation—the changes to the microworld had similar effects regardless of standing on these traits, F's range from less than 0.001 to 2.18,[4] and p values $> .10$. Aside from the shifts in conditions of the microworld, confusion was expected to change as a function of learning and failures to learn the underlying system. The averages of confusion across all the time points ranged from 1.57 (time point 7) to 3.25 (time point 20), indicating a large effect for the overall range of time points, $F(1, 160) = 122.54$, $p < .001$, $d = 1.07$. Together, these findings suggest that the experimental task and design had the desired effect of producing a large range in confusion.

Descriptive statistics and correlations between personality variables and interest-confusion relations are reported in Table 5. Unlike Studies 2 and 3, interest and confusion were almost unrelated ($r = -.06$) on average, but in line with the previous studies this relation varied substantially between people ($SD = .43$; Figure 5). Based on findings from Studies 1, 2, and 3, we speculated that the average interest-confusion relation varied as a function of the nature of the stimulus—less negative relations for artistic stimuli (Studies 1 and 2) compared with science and philosophy (Study 2), and psychology lectures (Study 3). The finding that that the interest-confusion relation is close to zero in the current study suggests that these differences are more nuanced. One possible reason why the average relation is close to zero in this study is that ratings are in response to a single stimulus—the microworld simulation—as opposed to the multiple stimuli (of a similar nature) that were presented in Studies 2 and 3.

[4] The only F value higher than 0.77 was the 2.18 that was the interaction between openness/intellect and the second extinction condition.

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Table 5
Study 4 Descriptives and Pearson's Correlations Between Openness Measures and Within-Person Interest-Confusion Relations

Measures	Mean	*SD*	Intellectual curiosity	Aesthetic sensitivity	Creative imagination	NFC	Intellect (Mussel)	Seek	Conquer	Think	Learn	Create	ICAR	Interest-confusion
BFI-2 openness/intellect	3.78	.82	.82**	.85**	.90**	.64**	.63**	.66**	.55**	.61**	.64**	.59**	.06	.22**
Intellectual curiosity	3.90	.90	1.00	.48**	.67**	.79**	.72**	.75**	.64**	.75**	.73**	.63**	.08	.20**
Aesthetic sensitivity	3.66	1.03		1.00	.66**	.31**	.34**	.35**	.31**	.31**	.38**	.31**	.02	.21**
Creative imagination	3.77	.94			1.00	.60**	.59**	.63**	.50**	.54**	.56**	.61**	.06	.14
NFC	3.41	.95				1.00	.87**	.88**	.78**	.89**	.84**	.79**	.14	.18*
Intellect (Mussel)	5.06	1.22					1.00	.97**	.96**	.97**	.97**	.96**	.04	.15
Seek	5.16	1.32						1.00	.86**	.94**	.94**	.93**	.07	.15
Conquer	4.96	1.21							1.00	.94**	.93**	.92**	.00	.14
Think	5.02	1.29								1.00	.93**	.89**	.07	.17*
Learn	5.27	1.14									1.00	.88**	.06	.15
Create	4.89	1.35										1.00	−.02	.13
ICAR	8.63	3.63											1.00	.09
Interest-confusion	−.06	.43												

Note. BFAS = Big Five Aspects Scales; OI = openness/intellect; NFC = Need for Cognition; BFI-2 = Big Five Inventory−2; ICAR = International Cognitive Ability Resource.
* $p < .05$. ** $p < .01$.

To test our hypothesis as outlined in the preregistration analysis plan, variance in interest-confusion relations was correlated with measures of openness/intellect. As predicted, more positive interest-confusion relations were associated with the openness/intellect domain and the facets of intellectual curiosity and aesthetics, NFC, and the think operation of Mussel's intellect scale (Table 6; see Table 2 for multilevel results)—the effect size of these relations is medium and similar to the effect sizes observed in the previous studies. The ICAR measure was not significantly associated with interest-confusion relations. Further, no other facet or domain of the BFI-2 was significantly related to interest-confusion relation variance (S1)—further supporting the importance of the openness/intellect domain in understanding individual differences in this within-person relation.

To test the unique influence of specific traits on the interest-confusion relations we used multilevel models (see Table 2). To test the particular influence of openness versus intellect on our variable of interest, we used the BFI-2 facets of aesthetic sensitivity and intellectual curiosity as concurrent predictors. According to Soto and John (2017), the aesthetic sensitivity facet shares the most variance with the BFAS openness measure, and intellectual curiosity is the best indicator of intellect. The analysis showed that, when modeled concurrently, neither of the facets significantly predict interest-confusion relations—suggesting that it is the shared variance driving the bivariate results. Next, we tested whether NFC—a trait particularly relevant for engagement with complex problem-solving tasks (Rudolph, Greiff, Strobel, & Preckel, 2018)—incrementally predicted interest-confusion relations over and above the openness/intellect domain. Similarly to the facets model, neither variable remained significant—although the domain was a stronger predictor—further pointing to the importance of the shared variance of these constructs in predicting interest-confusion relations (see Table 2). Thus, these results do not provide a clear indication of whether it is intellect or openness that underlies individual differences in interest-confusion relations in response to the used task. Finally, controlling for the other domains did not change the significant influence of openness/intellect on interest-confusion relations, with no other domain emerging as a significant predictor (supplementary material S1, Table S9).

Next, we tested our second preregistered prediction of a suppression effect between seek and conquer traits in predicting interest-confusion relations. Because high seek scores reflects a general motivation to engage with information, while high conquer scores reflect a motivation to master new information, we predicted that seek, as opposed to conquer would be particularly predictive of more positive interest-confusion relations. The hypothesis was not supported (see Table 2), the unique variance of seek and conquer processes did not significantly predict interest-confusion relations, but the overall scale—in the multilevel model—was significantly associated with more positive interest-confusion relations. It should be noted that, in this sample, all the scales of intellect were very highly correlated (average $r = .92$), including seek and conquer scales ($r = .89$), leaving little unique variance. It is not clear why these correlations were particularly high in this sample; however, the scales were also highly correlated in the validation study for the construct (Mussel, 2013). As Mussel himself has pointed out, different measures of curiosity are hard to distinguish, therefore, lacking discriminant validity (Mussel, 2010). The same seems to hold, at least in this sample, for the different scales within Mussel's measure, making it difficult to say much about the distinctions between them.

Finally, we wanted to make sure that our findings on the association between openness/intellect and the interest-confusion relation remained significant with the inclusion of intelligence in the models. When the ICAR measure was modeled concurrently with the BFI-2 openness/intellect domain, openness/intellect remained associated with more positive interest-confusion relations ($b = 0.09$, $SE = 0.32$, $p = .003$), and ICAR was not significantly related to the dependent variable ($b = 0.03$, $SE = 0.35$, $p = .34$). Thus, the relation of openness/intellect with more positive interest confusion relations was not affected by the inclusion of intelligence in the model.

General Discussion

When people are exposed to novel and complex information, interest and confusion are arguably the most frequent and important states that will determine the quality of the overall experience. While the importance of these states has been previously demonstrated in isolation, the within-person relations between these states have received little attention in the past. Given the appraisal structure of interest and confusion we predicted a negative within-

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

person relation between the states.[5] Because openness/intellect describes individual differences in cognitive exploration and the tendency of the open to be interested in novelty and complexity, we expected that openness/intellect would be associated with more positive relations between interest and confusion—thus, providing an insight into a phenomenological aspect of the domain.

Applying correlational and experimental methods, with varying situations and measures, our predictions regarding the average interest-confusion relation received mixed support—confirmed in two of the four studies that tested this relation. We observed that the average within-person relation between interest and confusion varied between the studies—for visual art stimuli the relation was close to zero (Studies 1 and 2), as it was during the course of a complex problem solving task (Study 5), while for science and philosophy stimuli, and psychology lectures the relation was negative. Consistently, this relation differed substantially between people—so much so that across studies a substantial number of people (39%) had positive relations between the states (Figures 1–4). This finding should be particularly informative for the fields of education and affective computing where these states are often considered as bipolar. The stark individual differences—not only in degree but in direction—make the discussion of the average tendency rather uninformative, at the same time making individual differences of greater importance.

As predicted, openness/intellect—as opposed to the other personality domains and intelligence—was consistently associated with more positive interest-confusion relations. In fact, given the large number of people that had positive relations between the states, our findings suggest that open people are more likely to have a positive relation between interest and confusion. To test this statistically, we ran post hoc logistic regressions and found that openness/intellect was associated with a greater likelihood of having a positive interest-confusion relation—a person that is a *SD* above the mean on openness/intellect is 1.52 times more likely to have a positive relation (see supplementary material S4 for results). Thus, not only does openness predict more positive interest-confusion relations, it also predicts the likelihood of this difference being one of direction, rather than just degree.

With regards to the distinction between the openness and intellect aspects of the domain, the evidence is mixed. There is some evidence that the tendency to have more positive interest-confusion relations is primarily associated with the openness aspect (Studies 1, 2, and 5); however, there is also evidence that in learning contexts, intellect also plays an important role (Studies 3 and 5). While no strong conclusion can be drawn with regards to the aspects, the relationship with the domain is quite robust. Below we discuss the implications of these findings in terms of what they may mean for engagement with complex information and learning.

Interest-Confusion Relations and Engagement With Complex Information

How should more positive interest-confusion relations be interpreted? It is tempting to interpret our findings as saying something about the co-occurrence of these states. However, this is somewhat problematic because a correlation between two states—although previously interpreted in this way—does not necessarily imply co-occurrence. As thoroughly investigated by Larsen and colleagues, when measures of correlation between two states are compared with other ways of assessing co-occurrence in experiments directly designed to elicit mixed emotions, the correlations do not fare well (Larsen, Hershfield, Stastny, & Hester, 2017). Instead they suggest that the best measure to assess co-occurrence is the MIN measure that is the averaged sum of the minimums of two states. While this measure appears to be most appropriate in the context of experiments designed to elicit mixed emotions, it is problematic when assessing mixed emotions in daily life and in the current studies. In daily life, the MIN measure basically tracks the less frequently occurring state—correlation with mean negative affect of .8 to .9 across several samples that we have tried to use it on. In the current studies, the problematic correlation is with confusion—relations between the MIN and average confusion are problematically high (Study 1 = .86, Study 2 = .75, Study 3 = .89, and Study 5 = .76). Thus, because the state-of-the-art measure of co-occurrence is less so in contexts where mixed emotions are not explicitly elicited, we are left with the correlation.

In other research that investigates the correlations between states, individual differences in such relations are discussed with reference to the degree of bipolarity—for example, daily life negative (NA) and positive affect (PA) are more bipolar for those scoring higher on depression (Dejonckheere et al., 2018). Unlike the PA-NA bipolarity research—where such relations are on average strongly negative—as reported above our samples include a substantial amount of people for whom the interest-confusion relation is actually positive. Therefore, degree of bipolarity is not an accurate way to consider differences in interest-confusion relations. Ultimately, we will tentatively interpret our correlational findings to be meaningful in terms of likelihood of co-occurrence. That is, we take a weak or positive correlation between interest and confusion to mean that such a person is more likely to report interest *and* confusion in response to a situation. Conversely, a person with a negative interest-confusion relation is more likely to have less interest when strong confusion is present and vice versa.

One could speculate that the co-occurrence of interest and confusion is the essence of curiosity. An important and underdiscussed issue with interest and curiosity research is whether the feeling precedes or follows understanding. In some ways, the appraisal perspective suggests that interest is felt as a function of understanding. However, others have suggested that curiosity is a feeling in response to a knowledge gap and precedes understanding (Loewenstein, 1994). In line with this view, interest about answers trivia questions (for which the answers are not known) is associated with reward circuitry activation (Gruber, Gelman, & Ranganath, 2014; Kang et al., 2009), suggesting that curiosity before knowing motivates information seeking behavior (Murayama, FitzGibbon, & Sakaki, 2018 preprint). According to Murayama et al. (2018 preprint), such interest before knowing results from previous rewarding experiences of successful knowledge

[5] Studies 1–3 included appraisal measures allowing for a direct test of the hypothesis that the relation between openness/intellect and interest confusion relations is statistically associated with emotion-appraisal differences. Because emotions and appraisals are difficult to disentangle and are likely to influence each other dynamically (Lewis, 2005), no causal claims are possible with our data. Therefore, we did not focus on appraisals within this article. However, we present the statistical mediation results in the online supplementary materials, which consistently supported our prediction in Studies 1–3 (S3).

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

acquisition which, over time, condition experiences where a subsequent knowledge gap is made salient—such as experiences of confusion. This process leads to an increase in the expected value of information. Murayama and colleagues also suggest that such motivation for information seeking behavior is contingent on the expected value of the information and the perceived ability to acquire the information.

Our findings regarding the association between openness/intellect and more positive interest-confusion relations can be used to integrate individual differences into this process account of engagement with information, and provide support for a theory suggesting that openness/intellect is associated with sensitivity to the reward value of information (DeYoung, 2013). Given that openness/intellect is associated with broad interests and intrinsic motivation of all sorts of information, open people are more likely to have higher expectations for the value of new information. Further, openness/intellect is consistently associated with greater coping potential appraisals in response to complex information (Fayn, MacCann, et al., 2015; Fayn et al., 2017; Fayn, Tiliopoulos, et al., 2015; Silvia, 2008), suggesting higher perceived ability to acquire new information. Thus, linking these two tendencies to Murayama's proposed contingencies suggests that open people are more likely to be motivated by the salience of complex new information, which we propose is associated with more positive interest-confusion relations. In support of this integration, Käckenmester and colleagues recently demonstrated that openness, but not intellect, was associated with greater motivational sensitivity to perceptual uncertainty—open participants were particularly motivated to receive information in conditions of uncertainly (Käckenmester, Kroencke, & Wacker, 2018).

Interest-Confusion, Openness/Intellect, and Learning Dynamics

One way to consider what individual differences in this relation practically imply is to consider the functions of the two emotions. The functions of interest are to motivate learning, and to be a counterweight to anxiety and enjoyment (Silvia, 2017). The function of confusion is thought to be a signal that the current situation presents an impasse to understanding the situation, and is meant to motivate greater investment of resources toward gaining insight (D'Mello & Graesser, 2012). Considering these functions together, both states are central to the process of evaluating, engaging with, and learning information. Given our findings, rather than considering these states separately, it seems useful to consider their relation also.

What are the implications for learning and engaging with new information for a closed-minded individual for whom confusion is more likely to be laced with a lack of interest, compared with an open person for whom these two states are more independent or even positive? The states of interest and confusion are central to educational outcomes in that they are (a) two of the most frequently occurring states during learning (D'Mello, 2013); (b) both positive predictors of learning gains (D'Mello et al., 2014); and (c) transitions between the two states are the most frequent observed during complex learning (D'Mello & Graesser, 2012). In their dynamic model, D'Mello and Graesser propose that complex learning occurs as a result of overcoming encountered impasses (confusion) and returning to interested engagement. Critically, this model of dynamics is based on a methodology that forces bipolarity—participants only report one state at each time point. According to our findings, however, assuming that confusion implies a lack of interest and vice versa is not justified—particularly when individual differences are considered.

Based on our findings, we would expect those low on openness/intellect—more negative interest-confusion relations—to be more likely to experience a lack of interest when experiencing confusion, which would increase the likelihood of transitioning to frustration and ultimately boredom. Open individuals, on the other hand, may be more likely to persist in trying to resolve confusion and may even, in some situations, be motivated and interested in the face of confusion. Therefore, we would predict that open people are more likely to experience transitions between interest and confusion, rather than descend into frustration and boredom. In line with this prediction, a recent review in the field of affective computing, made a similar suggestion—that confusion is particularly beneficial for learning when accompanied by interest (Harley, Lajoie, Frasson, & Hall, 2017).

The dynamic predictions proposed above could contribute to a future understanding of the relationship between openness/intellect and learning. While models for the relations between investment traits and the development of knowledge, cognitive abilities, and academic achievement are prevalent in the literature (Ackerman & Heggestad, 1997; von Stumm, Hell, & Chamorro-Premuzic, 2011; Ziegler, Danay, Heene, Asendorpf, & Bühner, 2012), a fine-grained understanding of these relations is still lacking. The broad proposal for the influence of openness/intellect on learning is through greater motivation and diligence in their approach toward information and knowledge acquisition, and greater likelihood of experiencing learning situations. Additionally, interests are also considered to moderate learning—learning is facilitated by the combination of willingness to learn and an alignment with interests. Such proposed mechanisms are very broad and difficult to test. A more fine-grained prediction based on the reward learning model described above (Murayama et al., 2018), is that those higher in openness/intellect are more sensitive to the reward value of complex and confusing information (DeYoung, 2013), a tendency that may manifest as more positive interest-confusion relations.

One possibility for more positive interest-confusion relation among the open is because of the associations between openness/intellect and interests. This could partially explain the influence of openness versus intellect in the different studies—intellect, which aligns most with investigative interests, being related to interest-confusion relations for psychology lectures and the microworld task (Studies 3 and 5), and openness, aligning more with artistic interests, being related to interest-confusion relations for art (Study 1). However, the role of openness also manifested in Studies 2 and 5, which, as has been shown previously (Fayn et al., 2017), could be because of openness reflecting broad interests in many epistemic situations.

Conclusion

The current research suggests that openness/intellect is associated with more positive relations between interest and confusion—a difference not only in degree but possibly direction of the relation—openness/intellect being associated with greater likeli-

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

hood of a positive interest-confusion relation. Such interest in the face of confusion may be akin to experiences of epistemic beauty: "the exhilarating prospect of mastering a challenging world" (Armstrong & Detweiler-Bedell, 2008, p. 305). Given the importance of these states in epistemic and learning contexts, and the association between openness/intellect and learning outcomes, we believe that our findings provide support for openness/intellect being associated with sensitivity to the reward value of information and can be the basis of new hypotheses regarding the processes underlying individual differences in learning.

References

Ackerman, P. L., & Heggestad, E. D. (1997). Intelligence, personality, and interests: Evidence for overlapping traits. *Psychological Bulletin, 121,* 219–245. http://dx.doi.org/10.1037/0033-2909.121.2.219

Armstrong, T., & Detweiler-Bedell, B. (2008). Beauty as an emotion: The exhilarating prospect of mastering a challenging world. *Review of General Psychology, 12,* 305–329. http://dx.doi.org/10.1037/a0012558

Bai, H. (2018). *Evidence that a large amount of low quality responses on MTurk can be detected with repeated GPS coordinates*. Retrieved from https://www.maxhuibai.com/blog/evidence-that-responses-from-repeating-gps-are-random

Barford, K., Fayn, K., Silvia, P. J., & Smillie, L. D. (2018). Individual differences in conflicting stimulus evaluations: Openness/Intellect predicts mixed-valenced appraisals of visual art. *Journal of Research in Personality, 73,* 46–55. http://dx.doi.org/10.1016/j.jrp.2017.11.006

Barford, K. A., & Smillie, L. D. (2016). Openness and other Big Five traits in relation to dispositional mixed emotions. *Personality and Individual Differences, 102,* 118–122. http://dx.doi.org/10.1016/j.paid.2016.07.002

Birney, D. P., Beckmann, J. F., Beckmann, N., Double, K. S., & Whittingham, K. (2018). Moderators of learning and performance trajectories in microworld simulations: Too soon to give up on intellect!? *Intelligence, 68,* 128–140. http://dx.doi.org/10.1016/j.intell.2018.03.008

Cacioppo, J. T., Petty, R. E., & Kao, C. F. (1984). The efficient assessment of need for cognition. *Journal of Personality Assessment, 48,* 306–307. http://dx.doi.org/10.1207/s15327752jpa4803_13

Coifman, K. G., Berenson, K. R., Rafaeli, E., & Downey, G. (2012). From negative to positive and back again: Polarized affective and relational experience in borderline personality disorder. *Journal of Abnormal Psychology, 121,* 668–679. http://dx.doi.org/10.1037/a0028502

Condon, D. M., & Revelle, W. (2014). The International Cognitive Ability Resource: Development and initial validation of a public-domain measure. *Intelligence, 43,* 52–64.

Costa, P. T., & McCrae, R. R. (1992). Normal personality assessment in clinical practice: The NEO Personality Inventory. *Psychological Assessment, 4,* 5–13. http://dx.doi.org/10.1037/1040-3590.4.1.5

Cotter, K. N., Silvia, P. J., & Fayn, K. (2018). What does feeling like crying when listening to music feel like? *Psychology of Aesthetics, Creativity, and the Arts, 12,* 216–227. http://dx.doi.org/10.1037/aca0000108

Craig, S., Graesser, A., Sullins, J., & Gholson, B. (2004). Affect and learning: An exploratory look into the role of affect in learning with AutoTutor. *Journal of Educational Media, 29,* 241–250. http://dx.doi.org/10.1080/1358165042000283101

Dejonckheere, E., Mestdagh, M., Houben, M., Erbas, Y., Pe, M., Koval, P., . . . Kuppens, P. (2018). The bipolarity of affect and depressive symptoms. *Journal of Personality and Social Psychology, 114,* 323–341. http://dx.doi.org/10.1037/pspp0000186

DeYoung, C. G. (2013). The neuromodulator of exploration: A unifying theory of the role of dopamine in personality. *Frontiers in Human Neuroscience, 7,* 762. http://dx.doi.org/10.3389/fnhum.2013.00762

DeYoung, C. G. (2015). Openness/intellect: A dimension of personality reflecting cognitive exploration. In M. Mikulincer, P. R. Shaver, M. L. Cooper, & R. J. Larsen (Eds.), *APA handbook of personality and social psychology: Personality processes and individual differences* (Vol. 4, pp. 369–399). Washington, DC: American Psychological Association. http://dx.doi.org/10.1037/14343-017

DeYoung, C. G., Quilty, L. C., & Peterson, J. B. (2007). Between facets and domains: 10 aspects of the Big Five. *Journal of Personality and Social Psychology, 93,* 880–896. http://dx.doi.org/10.1037/0022-3514.93.5.880

D'Mello, S. (2013). A selective meta-analysis on the relative incidence of discrete affective states during learning with technology. *Journal of Educational Psychology, 105,* 1082–1099. http://dx.doi.org/10.1037/a0032674

D'Mello, S., & Graesser, A. (2011). The half-life of cognitive-affective states during complex learning. *Cognition and Emotion, 25,* 1299–1308. http://dx.doi.org/10.1080/02699931.2011.613668

D'Mello, S., & Graesser, A. (2012). Dynamics of affective states during complex learning. *Learning and Instruction, 22,* 145–157. http://dx.doi.org/10.1016/j.learninstruc.2011.10.001

D'Mello, S., Lehman, B., Pekrun, R., & Graesser, A. (2014). Confusion can be beneficial for learning. *Learning and Instruction, 29,* 153–170. http://dx.doi.org/10.1016/j.learninstruc.2012.05.003

Ellsworth, P. C., & Scherer, K. R. (2003). Appraisal processes in emotion. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Series in affective science. Handbook of affective sciences* (pp. 572–595). New York, NY: Oxford University Press.

Erbas, Y., Ceulemans, E., Koval, P., & Kuppens, P. (2015). The role of valence focus and appraisal overlap in emotion differentiation. *Emotion, 15,* 373–382. http://dx.doi.org/10.1037/emo0000039

Erbas, Y., Ceulemans, E., Lee Pe, M., Koval, P., & Kuppens, P. (2014). Negative emotion differentiation: Its personality and well-being correlates and a comparison of different assessment methods. *Cognition and Emotion, 28,* 1196–1213. http://dx.doi.org/10.1080/02699931.2013.875890

Fayn, K., MacCann, C., Tiliopoulos, N., & Silvia, P. J. (2015). Aesthetic emotions and aesthetic people: openness predicts sensitivity to novelty in the experiences of interest and pleasure. *Frontiers in Psychology, 6,* 1877. http://dx.doi.org/10.3389/fpsyg.2015.01877

Fayn, K., Silvia, P. J., Erbas, Y., Tiliopoulos, N., & Kuppens, P. (2018). Nuanced aesthetic emotions: Emotion differentiation is related to knowledge of the arts and curiosity. *Cognition and Emotion, 32,* 593–599. http://dx.doi.org/10.1080/02699931.2017.1322554

Fayn, K., Silvia, P. J., MacCann, C., & Tiliopoulos, N. (2017). Interested in different things or in different ways? Exploring the engagement distinction between openness and intellect. *Journal of Individual Differences, 38,* 265–273. http://dx.doi.org/10.1027/1614-0001/a000243

Fayn, K., Tiliopoulos, N., & MacCann, C. (2015). Interest in truth versus beauty: Intellect and openness reflect different pathways towards interest. *Personality and Individual Differences, 81,* 47–52. http://dx.doi.org/10.1016/j.paid.2014.12.031

Furnham, A., & Marks, J. (2013). Tolerance of ambiguity: A review of the recent literature. *Psychology, 4,* 717–728. http://dx.doi.org/10.4236/psych.2013.49102

Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and Individual Differences, 102,* 74–78. http://dx.doi.org/10.1016/j.paid.2016.06.069

Grossmann, I., Huynh, A. C., & Ellsworth, P. C. (2016). Emotional complexity: Clarifying definitions and cultural correlates. *Journal of Personality and Social Psychology, 111,* 895–916. http://dx.doi.org/10.1037/pspp0000084

Gruber, M. J., Gelman, B. D., & Ranganath, C. (2014). States of curiosity modulate hippocampus-dependent learning via the dopaminergic circuit. *Neuron, 84,* 486–496. http://dx.doi.org/10.1016/j.neuron.2014.08.060

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Grühn, D., Lumley, M. A., Diehl, M., & Labouvie-Vief, G. (2013). Time-based indicators of emotional complexity: Interrelations and correlates. *Emotion, 13,* 226–237. http://dx.doi.org/10.1037/a0030363

Harley, J. M., Lajoie, S. P., Frasson, C., & Hall, N. C. (2017). Developing emotion-aware, advanced learning technologies: A taxonomy of approaches and features. *International Journal of Artificial Intelligence in Education, 27,* 268–297. http://dx.doi.org/10.1007/s40593-016-0126-8

Izard, C. E. (1977). *Human emotions*. New York, NY: Plenum Press.

Jach, H., & Smillie, L. D. (2019). Appreciating the unknown: How tolerance for ambiguity relates to openness, extraversion, and neuroticism. *Journal of Research in Personality*. Advance online publication. http://dx.doi.org/10.1016/j.jrp.2019.02.003

Käckenmester, W., Kroencke, L., & Wacker, J. (2018). Frontal asymmetry predicts the incentive value of perceptual information. *International Journal of Psychophysiology, 134,* 22–29. http://dx.doi.org/10.1016/j.ijpsycho.2018.10.002

Kang, M. J., Hsu, M., Krajbich, I. M., Loewenstein, G., McClure, S. M., Wang, J. T., & Camerer, C. F. (2009). The wick in the candle of learning: Epistemic curiosity activates reward circuitry and enhances memory. *Psychological Science, 20,* 963–973. http://dx.doi.org/10.1111/j.1467-9280.2009.02402.x

Kashdan, T. B., Barrett, L. F., & McKnight, P. E. (2015). Unpacking emotion differentiation: Transforming unpleasant experience by perceiving distinctions in negativity. *Current Directions in Psychological Science, 24,* 10–16. http://dx.doi.org/10.1177/0963721414550708

Kashdan, T. B., Gallagher, M. W., Silvia, P. J., Winterstein, B. P., Breen, W. E., Terhar, D., & Steger, M. F. (2009). The curiosity and exploration inventory-II: Development, factor structure, and psychometrics. *Journal of Research in Personality, 43,* 987–998. http://dx.doi.org/10.1016/j.jrp.2009.04.011

Kaufman, S. B., Quilty, L. C., Grazioplene, R. G., Hirsh, J. B., Gray, J. R., Peterson, J. B., & DeYoung, C. G. (2016). Openness to experience and intellect differentially predict creative achievement in the arts and sciences. *Journal of Personality, 84,* 248–258. http://dx.doi.org/10.1111/jopy.12156

Kuppens, P., & Tong, E. M. W. (2010). An appraisal account of individual differences in emotional experience. *Social and Personality Psychology Compass, 4,* 1138–1150. http://dx.doi.org/10.1111/j.1751-9004.2010.00324.x

Larsen, J. T., Hershfield, H. E., Stastny, B. J., & Hester, N. (2017). On the relationship between positive and negative affect: Their correlation and their co-occurrence. *Emotion, 17,* 323–336. http://dx.doi.org/10.1037/emo0000231

Lewis, M. D. (2005). Bridging emotion theory and neurobiology through dynamic systems modeling. *Behavioral and Brain Sciences, 28,* 169–194. http://dx.doi.org/10.1017/S0140525X0500004X

Loewenstein, G. (1994). The psychology of curiosity: A review and reinterpretation. *Psychological Bulletin, 116,* 75–98. http://dx.doi.org/10.1037/0033-2909.116.1.75

MacLeod, S. (1999). *The life of Haifisch*. Lawrence, KS: Broken Boulder Press. Retrieved from http://www.brokenboulder.com/books/sm-cov.pdf

McCabe, K. O., Mack, L., & Fleeson, W. (2012). A guide for data cleaning in experience sampling studies. In M. R. Mehl & T. S. Connor (Eds.), *Handbook of research methods for studying daily life* (pp. 321–338). New York, NY: Guilford Press.

McCullough, M. E., Emmons, R. A., & Tsang, J. A. (2002). The grateful disposition: A conceptual and empirical topography. *Journal of Personality and Social Psychology, 82,* 112–127. http://dx.doi.org/10.1037/0022-3514.82.1.112

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods, 7*(1), 105–125.

Murayama, K., FitzGibbon, L., & Sakaki, M. (2018). Process account of curiosity and interest: A reward learning model of knowledge acquisition. Advance online publication. http://dx.doi.org/10.31219/osf.io/hbcz5

Mussel, P. (2010). Epistemic curiosity and related constructs: Lacking evidence of discriminant validity. *Personality and Individual Differences, 49,* 506–510. http://dx.doi.org/10.1016/j.paid.2010.05.014

Mussel, P. (2013). Intellect: A theoretical framework for personality traits related to intellectual achievements. *Journal of Personality and Social Psychology, 104,* 885–906. http://dx.doi.org/10.1037/a0031918

Muthén, L. K., & Muthén, B. O. (1998–2012). *Mplus user's guide* (7th ed.). Los Angeles, CA: Author.

Ong, A. D., Zautra, A. J., & Finan, P. H. (2017). Inter-and intra-individual variation in emotional complexity: Methodological considerations and theoretical implications. *Current Opinion in Behavioral Sciences, 15,* 22–26.

Pe, M. L., & Kuppens, P. (2012). The dynamic interplay between emotions in daily life: Augmentation, blunting, and the role of appraisal overlap. *Emotion, 12,* 1320–1328. http://dx.doi.org/10.1037/a0028262

Poropat, A. E. (2009). A meta-analysis of the five-factor model of personality and academic performance. *Psychological Bulletin, 135,* 322–338. http://dx.doi.org/10.1037/a0014996

Rudolph, J., Greiff, S., Strobel, A., & Preckel, F. (2018). Understanding the link between need for cognition and complex problem solving. *Contemporary Educational Psychology, 55,* 53–62. http://dx.doi.org/10.1016/j.cedpsych.2018.08.001

Schiefele, U., & Csikszentmihalyi, M. (1994). Interest and the quality of experience. *European Journal of Psychology of Education, 10,* 251–270. Retrieved from http://www.springerlink.com/index/812737326H040572.pdf

Shiota, M. N., Keltner, D., & John, O. P. (2006). Positive emotion dispositions differentially associated with Big Five personality and attachment style. *The Journal of Positive Psychology, 1,* 61–71. http://dx.doi.org/10.1080/17439760500510833

Silvia, P. J. (2005). What is interesting? Exploring the appraisal structure of interest. *Emotion, 5,* 89–102. http://dx.doi.org/10.1037/1528-3542.5.1.89

Silvia, P. J. (2008). Appraisal components and emotion traits: Examining the appraisal basis of trait curiosity. *Cognition and Emotion, 22,* 94–113. http://dx.doi.org/10.1080/02699930701298481

Silvia, P. J. (2009). Looking past pleasure: Anger, confusion, disgust, pride, surprise, and other unusual aesthetic emotions. *Psychology of Aesthetics, Creativity, and the Arts, 3,* 48–51. http://dx.doi.org/10.1037/a0014632

Silvia, P. J. (2010). Confusion and interest: The role of knowledge emotions in aesthetic experience. *Psychology of Aesthetics, Creativity, and the Arts, 4,* 75–80. http://dx.doi.org/10.1037/a0017081

Silvia, P. J. (2017). Curiosity. In P. O'Keefe & J. Harackiewicz (Eds.), *The science of interest* (pp. 97–107). Cham: Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-55509-6_5

Silvia, P. J., Fayn, K., Nusbaum, E. C., & Beaty, R. E. (2015). Openness to experience and awe in response to nature and music: Personality and profound aesthetic experiences. *Psychology of Aesthetics, Creativity, and the Arts, 9,* 376–384. http://dx.doi.org/10.1037/aca0000028

Silvia, P. J., Henson, R. A., & Templin, J. L. (2009). Are the sources of interest the same for everyone? Using multilevel mixture models to explore individual differences in appraisal structures. *Cognition & Emotion, 23,* 1389–1406. http://dx.doi.org/10.1080/02699930902850528

Silvia, P. J., & Nusbaum, E. C. (2011). On personality and piloerection: Individual differences in aesthetic chills and other unusual aesthetic experiences. *Psychology of Aesthetics, Creativity, and the Arts, 5,* 208–214. http://dx.doi.org/10.1037/a0021914

Smillie, L. D., Varsavsky, V., Avery, R. E., & Perry, R. (2016). Trait intellect predicts cognitive engagement: Evidence from a resource allocation perspective. *European Journal of Personality, 30,* 215–226. http://dx.doi.org/10.1002/per.2059

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.

Smith, L. F., & Smith, J. K. (2006). The nature and growth of aesthetic fluency. In P. Locher, C. Martindale, & L. Dorfman (Eds.), *New directions in aesthetics, creativity, and the arts* (pp. 47–58). Amityville, NY: Baywood.

Steel, P., Schmidt, J., & Shultz, J. (2008). Refining the relationship between personality and subjective well-being. *Psychological Bulletin, 134,* 138–161. http://dx.doi.org/10.1037/0033-2909.134.1.138

Soto, C. J., & John, O. P. (2017). The next Big Five Inventory (BFI-2): Developing and assessing a hierarchical model with 15 facets to enhance bandwidth, fidelity, and predictive power. *Journal of Personality and Social Psychology, 113*(1), 117–143.

Summerville, A., & Roese, N. J. (2008). Self-report measures of individual differences in regulatory focus: A cautionary note. *Journal of Research in Personality, 42,* 247–254. http://dx.doi.org/10.1016/j.jrp.2007.05.005

Tellegen, A., & Atkinson, G. (1974). Openness to absorbing and self-altering experiences ("absorption"), a trait related to hypnotic susceptibility. *Journal of Abnormal Psychology, 83,* 268–277. http://dx.doi.org/10.1037/h0036681

Terracciano, A., McCrae, R. R., Hagemann, D., & Costa, P. T., Jr. (2003). Individual difference variables, affective differentiation, and the structures of affect. *Journal of Personality, 71,* 669–704. http://dx.doi.org/10.1111/1467-6494.7105001

Tomkins, S. S. (1962). *Affect, imagery, consciousness: Vol. 1. The positive affects*. New York, NY: Springer.

Tong, E. M. W., & Jia, L. (2017). Positive emotion, appraisal, and the role of appraisal overlap in positive emotion co-occurrence. *Emotion, 17,* 40–54. http://dx.doi.org/10.1037/emo0000203

TurkPrime. (2018, September 18). After the bot scare: Understanding what's been happening with data collection on MTurk and how to stop it. [Blog post]. Retrieved from https://blog.turkprime.com/after-the-bot-scare-understanding-whats-been-happening-with-data-collection-on-mturk-and-how-to-stop-it

von Stumm, S., & Ackerman, P. L. (2013). Investment and intellect: A review and meta-analysis. *Psychological Bulletin, 139,* 841–869. http://dx.doi.org/10.1037/a0030746

von Stumm, S., Hell, B., & Chamorro-Premuzic, T. (2011). The hungry mind: Intellectual curiosity is the third pillar of academic performance. *Perspectives on Psychological Science, 6,* 574–588. http://dx.doi.org/10.1177/1745691611421204

Watkins, P. C., Woodward, K., Stone, T., & Kolts, R. L. (2003). Gratitude and happiness: Development of a measure of gratitude, and relationships with subjective well-being. *Social Behavior and Personality, 31,* 431–451. http://dx.doi.org/10.2224/sbp.2003.31.5.431

Weibel, D., Wissmath, B., & Mast, F. W. (2010). Immersion in mediated environments: The role of personality traits. *Cyberpsychology, Behavior, and Social Networking, 13,* 251–256. http://dx.doi.org/10.1089/cyber.2009.0171

Woo, S. E., Chernyshenko, O. S., Longley, A., Zhang, Z.-X., Chiu, C.-Y., & Stark, S. E. (2014). Openness to experience: Its lower level structure, measurement, and cross-cultural equivalence. *Journal of Personality Assessment, 96,* 29–45. http://dx.doi.org/10.1080/00223891.2013.806328

Zautra, A. J., Berkhof, J., & Nicolson, N. A. (2002). Changes in affect interrelations as a function of stressful events. *Cognition and Emotion, 16,* 309–318. http://dx.doi.org/10.1080/02699930143000257

Ziegler, M., Danay, E., Heene, M., Asendorpf, J., & Bühner, M. (2012). Openness, fluid intelligence, and crystallized intelligence: Toward an integrative model. *Journal of Research in Personality, 46,* 173–183. http://dx.doi.org/10.1016/j.jrp.2012.01.002

Received September 28, 2017
Revision received May 7, 2019
Accepted May 21, 2019 ■

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of the individual user and is not to be disseminated broadly.