



## Open or opposed to unknowns: How do curious people think and feel about uncertainty?

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### ARTICLE INFO

#### Keywords:

Curiosity  
Interest  
Deprivation  
Attitude towards uncertainty

### ABSTRACT

**Background:** Curiosity is a psychological response to uncertainty that facilitates learning and other benefits, but little is known about how highly curious people interpret and process uncertainty differently from their less curious counterparts. We investigated the relationship between curiosity (both interest- and deprivation-type) and a variety of attitudes towards uncertainty.

**Method:** An adult sample from the United Kingdom ( $N = 398$ ) completed an online questionnaire measuring dispositional interest- and deprivation-type curiosity, positive attitudes towards uncertainty, intolerance of uncertainty, and tendencies to focus on potential positive or negative outcomes.

**Findings:** A higher score on interest was associated with finding uncertainty more enjoyable and focusing on positive possibilities. A higher score on deprivation was associated with being more intolerant of uncertainty and focusing on negative possibilities.

**Conclusion:** The connections between curiosity and attitudes towards uncertainty differ according to the type of curiosity experienced. Interest may reinforce learning by promoting a fascination with the unknown and a focus on positive discoveries. Deprivation may reinforce learning by promoting discomfort with the unknown and a focus on negative discoveries that one wishes to be reassured of or prepared for.

Curiosity is the desire to approach or engage with the unknown in order to learn or better understand something (Kashdan et al., 2009; Loewenstein, 1994). We can only be curious about what we do not know or understand, thus curiosity is a psychological reaction to uncertainty. Given this fact, it is likely that one's level of curiosity is intimately related to the way in which one psychologically processes uncertainty. However, despite the likely intimate relationship between curiosity and uncertainty attitudes, little is known about whether highly curious people think and feel about uncertainty differently from their less curious counterparts. This paper investigates the relationship between curiosity and both positive and negative attitudes towards uncertainty, and so we are primarily focusing on epistemic curiosity (the desire to acquire knowledge about something unknown; Litman, 2005).

Although empirical research is limited, the link between curiosity and uncertainty processes has long fascinated curiosity theorists. This is partly because certain aspects of curiosity seem to entail a high tolerance and enjoyment of uncertainty (because it involves willingly searching for unknowns and exploring them), whereas other aspects seem to entail a high intolerance of uncertainty (because curiosity is fundamentally

aimed at reducing uncertainty to improve understanding; Berlyne, 1966; Kashdan et al., 2018; Litman, Crowson, & Kolinski, 2010; Loewenstein, 1994; Reis-Dennis, Gerrity, & Geller, 2021; Spielberg & Starr, 1994).

The argument that curiosity inherently involves a high tolerance of uncertainty originated from the optimal-level theory of curiosity, which states that curiosity is the desire to alleviate boredom by seeking out stimulation from novelty and complexity (see Berlyne, 1966; Hebb, 1955; Litman & Jimerson, 2004). In support of this argument, studies have found that certain curiosity scales correlate positively with an appreciation of complexity (Jach & Smillie, 2019) and negatively with intolerance of uncertainty (Koerner, Mejia, & Kusec, 2017). Additionally, some scholars have placed curiosity in a contrast with anxiety, arguing that the former involves approaching new things out of interest and is a counterweight to the latter, which involves avoiding new things out of fear (Silvia, 2017). In one commonly used curiosity scale, the Curiosity and Exploration Inventory-II (Kashdan et al., 2009), researchers included a subscale measuring a person's tendency to embrace uncertainty, thereby suggesting that a positive and accepting attitude towards uncertainty is integral to high curiosity.

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However, others argue that curiosity involves an intolerance of uncertainty since curious people want to know things rather than keeping things unknown and mysterious (Litman & Jimerson, 2004; Loewenstein, 1994). This perspective emphasises that curiosity is a motivation to transform confusion into understanding, ignorance into knowledge, and questions into answers, all of which involve reducing uncertainty and appear to be the opposite of being tolerant of and content with uncertainty. This alternative view originated from the drive-reduction theory of curiosity (see Berlyne, 1960; Litman, 2005; Litman & Jimerson, 2004) which viewed curiosity as a discomforting feeling of uncertainty that individuals are motivated to reduce by acquiring the missing knowledge. The idea was later popularised by Loewenstein's (1994) information gap theory, which states that perceiving a gap between one's current state of knowledge and desired state of knowledge is an inherently unpleasant feeling of information deprivation that motivates exploration in order to gain relief. Neuroscientific evidence supports that inducing curiosity can activate neural regions associated with pain, discomfort, and cognitive conflict, suggesting that curiosity can operate as a desire to reduce displeasure caused by uncertainty (Jepma, Verdonschot, van Steenbergen, Rombouts, & Nieuwenhuis, 2012).

Although empirical research is limited, the results of some studies suggests that these two seemingly opposite hypotheses regarding curiosity's relationship with tolerance of uncertainty are not mutually exclusive, but instead apply to different types of curiosity (Litman, 2010). Researchers have demonstrated that epistemic curiosity can be divided into two types, each representing a different intrinsic motivation for learning (Litman, 2008). Interest-type curiosity (henceforth "interest") is motivated by the anticipation of enjoyment from learning, whereas deprivation-type curiosity (henceforth "deprivation") is aimed at reducing the tension and frustration associated with not knowing. These two curiosity types have repeatedly emerged as separate but correlated curiosity dispositions (Karandikar, Kapoor, & Litman, 2021; Litman, 2008; Litman & Mussel, 2013; Ryakhovskaya, Jach, & Smillie, 2022). Moreover, research has found that scoring higher on interest is associated with higher scores on the Tolerance for Ambiguity Scale (Mac Donald, 1970), whereas scoring higher on deprivation is associated with lower tolerance for ambiguity (Litman, 2010).

Until now, research has only investigated the general attitudes towards uncertainty linked to interest and deprivation (Litman, 2010). Curiosity theorists have proposed that more specific attitudes towards uncertainty may be linked to interest or deprivation, but these hypotheses have not been tested. One proposition is that interest and deprivation are related to different attitudes towards processing uncertainty, that is, how it feels to be uncertain ("process-focused attitudes" for short). Individuals who score highly on interest are thought to enjoy uncertainty because for them uncertainty represents an opportunity to wonder and explore (Berlyne, 1966; Litman, 2010; Litman & Jimerson, 2004; Spielberger & Starr, 1994). On the other hand, individuals who score highly on deprivation are thought to dislike uncertainty because they associate uncertainty with ignorance, a lack of understanding, and the existence of unsolved problems (Litman, 2010; Litman & Jimerson, 2004; Loewenstein, 1994). Ultimately, interest and deprivation are hypothesized to be linked to positive and negative process-focused attitudes towards uncertainty, respectively.

Another proposition is that interest and deprivation are related to different expectations about the outcomes of reducing uncertainty ("outcome-focused attitudes" for short). Theorists have suggested that a key source of pleasure involved in interest is the anticipation of positive outcomes resulting from exploring the knowledge gap, such as learning something brand new that is amusing or useful, or successfully acquiring the desired information (Berlyne, 1967; Lauriola et al., 2015; Litman, Hutchins, & Russon, 2005). Conversely, a key source of displeasure involved in deprivation is thought to be the anticipation of negative outcomes resulting from exploring the knowledge gap, such as learning something unpleasant or failing to acquire the desired information (Lauriola et al., 2015; Litman et al., 2005). Consequently, interest and

deprivation are also hypothesized to be associated with positive and negative outcome-focused attitudes towards uncertainty, respectively. This is similar to Higgins' theory on promotion- and prevention-focus goals, which states that individuals differ in the extent to which they orient themselves towards positive or negative outcomes when pursuing goals (Higgins, 1997).

To date, most research into the connections between curiosity and attitudes towards uncertainty has either not distinguished between interest and deprivation (e.g., Jach & Smillie, 2019; Koerner et al., 2017) or measured general attitudes towards uncertainty which do not differentiate between positive and negative attitudes, nor between process- and outcome-focused attitudes (e.g., Litman, 2010). One exception is Lauriola et al. (2015), which found that interest was associated with positive outcome expectancies whereas deprivation was associated with negative outcome expectancies, supporting the proposition that interest and deprivation are related to different outcome-focused attitudes. However, more robust testing of Litman's (2010) and Lauriola et al.'s (2015) findings in more diverse adult samples is needed. The samples in both studies consisted entirely of young undergraduates who are likely to be more curious than average (see Sakaki, Yagi, & Murayama, 2018 for a review).

The present study investigated the extent to which interest and deprivation are associated with positive and negative attitudes towards uncertainty, including process- and outcome-focused attitudes. In line with the propositions made by curiosity theorists, we predicted that higher interest is associated with more positive process-focused attitudes – specifically, the appraisal that uncertainty can generate pleasure ( $H_1$ ) – whereas higher deprivation is associated with more negative process-focused attitudes ( $H_2$ ). We also predicted that higher interest is associated with more positive outcome-focused attitudes ( $H_3$ ) whereas higher deprivation is associated with more negative outcome-focused attitudes ( $H_4$ ).

## 1. Method

### 1.1. Participants

We recruited 398 adult participants from the United Kingdom via the survey-hosting website Prolific (<https://www.prolific.co>). Participants were paid the typical rate for their involvement. We desired a variety of participant ages and used stratified-random sampling (stratified according to age groups) to achieve this. The sample was fairly representative of gender (201 female, 195 male, 2 non-binary, 2 prefer not to say), age ( $M = 46.31$ ,  $SD = 14.67$ , min-max = 18–84), and median gross household income (£38,750, which approximates the UK population median; Office for National Statistics, 2021). See Supplementary Materials (Section 1) for more detailed demographics.

### 1.2. Measures

*The I/D Epistemic Curiosity Scales* (Litman, 2008) assessed trait interest-type curiosity (five items) and trait deprivation-type curiosity (five items). Participants reported how often they experience the feelings described in each item using a four-point scale from 1 (*almost never*) to 4 (*almost always*).

*The Positive Unknowns Scales* (Smithson, Chen, & Shou, 2021) assessed the endorsement of a variety of positive beliefs about uncertainty using seven scales. The scales distinguish between unknowns involved in generating and maintaining pleasure (e.g., curiosity-driven discovery [six items], excitement and freedom from not knowing what the future holds [four items], pleasant surprises [three items]), avoiding negative consequences (e.g., negative emotions or unwanted culpability [five items], costly effort to understand complexity [four items]) and following social norms (e.g., respecting privacy [four items], acting on trust [three items]). Participants responded on a seven-point scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

**The Intolerance of Uncertainty Scale-12** (12 items; Carleton, Norton, & Asmundson, 2007) measured the endorsement of negative beliefs about uncertainty and its implications, including the tendency to react negatively to uncertainty on an emotional, cognitive, and behavioral level. Participants responded on a five-point scale from 1 (*not at all characteristic of me*) to 5 (*entirely characteristic of me*).

**The Elaboration on Potential Outcomes Scale** (Nenkov, Inman, & Hulland, 2008) measured participants' tendencies to consider potential outcomes during uncertain situations via: generating and evaluating different outcomes in one's mind (six items), focusing on positive outcomes (three items), and focusing on negative outcomes (four items). Participants responded using a seven-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

1.3. Procedure

The study was approved by the Australian National University's Human Research Ethics Committee (Protocol 2020/013). Participants were given a URL link to the survey on Qualtrics (<https://qualtrics.com>) and read a brief information sheet about the study before indicating their consent to participate. Participants then completed a questionnaire containing all demographic questions and psychological scales. Finally, participants were shown a debriefing sheet disclosing the study's aims and methods. The survey took 12.2 min to complete on average (*SD* = 5.2 min).

1.4. Analysis plan, type I error reduction, and power analysis

For each scale measuring an attitude towards uncertainty, we assessed (a) its correlation with interest, (b) its correlation with deprivation, and (c) whether these two correlations were significantly different. We assessed significance using a Bonferroni-corrected alpha for three comparisons ( $\alpha = 0.017$ ). We planned to run partial correlations (*pr*) to assess the relationships of interest and deprivation with each attitude scale, controlling for the other curiosity type to protect against masking effects (the possibility of interest and deprivation confounding one another's relationships due to being moderately correlated; Litman et al., 2010).

Prior to data collection, we ran power analyses using G\*Power (Faul, Erdfelder, Buchner, & Lang, 2009) to determine the required sample size to detect correlation of 0.20 (a medium effect size in personality research according to modern guidelines; Gignac & Szodorai, 2016) with high power (90 %) at the 0.017 alpha level. Analyses recommended a sample of at least 326 participants.

**Table 1**  
Descriptives and internal consistency statistics for all psychological scales.

Variable	Mean	SD	Min-Max	$\alpha$
Curiosity types				
Interest	14.33	3.00	5–20	0.84
Deprivation	11.70	3.47	5–20	0.85
Positive unknowns				
Discovery	32.94	4.61	15–42	0.72
Bad knowns	19.22	6.11	5–34	0.77
Privacy	17.30	4.49	4–28	0.70
Reliance on expertise	18.48	4.24	5–28	0.68
Positive future	17.12	4.13	4–27	0.78
Good surprises	17.68	3.54	3–21	0.75
Trust relations	15.69	2.98	5–21	0.71
Intolerance of uncertainty	36.06	8.86	12–60	0.90
Elaboration on potential outcomes				
Generation/evaluation	5.26	0.89	1.17–7.00	0.87
Positive outcome focus	4.76	1.24	1.00–7.00	0.84
Negative outcome focus	4.47	1.31	1.00–7.00	0.87

2. Results

The means, standard deviations, min-max values, and Cronbach's alphas for all psychological scales are displayed in Table 1. Most scales had good internal consistency, except for the Reliance on Expertise Scale which had alpha values lower than the conventional standard of 0.70. Additionally, we detected a strong ceiling effect for the Good Surprises Scale, with most participants scoring on the high end of the scale. We therefore interpreted results involving these two variables with caution.

Fig. 1 illustrates the main findings relevant to our hypotheses. This includes the partial correlations of interest and deprivation with scales assessing positive attitudes towards uncertainty (relevant to H<sub>1</sub>), intolerance of uncertainty (relevant to H<sub>2</sub>), and positive- and negative-outcome expectancies (relevant to H<sub>3</sub> and H<sub>4</sub>). See Supplementary Materials for more detailed correlation results, including confidence intervals and a zero-order correlation matrix between all variables, age, and sex, and common method variance analyses.

2.1. Curiosity and positive process-focused attitudes

As predicted (H<sub>1</sub>), partial correlations revealed that, after controlling for deprivation, interest was positively associated with the belief that generating and maintaining uncertainty can be pleasurable (a specific positive process-focused attitude). This included a moderate positive association with the Discovery Scale,  $pr = 0.421, t(395) = 9.23, p < .001$ , and positive future,  $pr = 0.277, t(395) = 5.73, p < .001$ . Contrary to predictions, interest was not significantly correlated with good surprises,  $pr = 0.047, t(395) = 0.94, p = .348$ , but this may be due to ceiling effects. Interest was not significantly related to other positive process-focused attitudes, including the belief that uncertainty can be used to avoid negative consequences (bad knowns, reliance on expertise) and follow social norms (privacy, trust relations),  $|prs| \leq 0.114, ts(395) \leq 2.29, ps \geq 0.023$ .

In contrast, deprivation had only a small correlation with the discovery belief,  $pr = 0.130, t(395) = 2.61, p = .009$ . Deprivation was not significantly associated with any other positive process-focused attitudes,  $|prs| \leq 0.104, ts(395) \leq 2.07, ps \geq 0.039$ . Chi-squared tests showed that deprivation had significantly lower correlations than interest with discovery,  $\chi^2_1 = 14.95, p < .001$ , and positive future,  $\chi^2_1 = 20.59, p < .001$ .

2.2. Curiosity and negative process-focused attitudes

Deprivation had a moderate positive association with intolerance of uncertainty,  $pr = 0.330, t(395) = 6.95, p < .001$ , supporting the prediction that higher deprivation is linked to stronger negative process-focused attitudes towards uncertainty (H<sub>2</sub>). Conversely, interest had a moderate negative association with intolerance of uncertainty,  $pr = -0.218, t(395) = 4.45, p < .001$ , suggesting that individuals scoring highly on interest tend to make less negative process-focused appraisals of uncertainty. Due to both correlations being significant and in opposite directions, a chi-squared test for a significant difference was not needed.

2.3. Curiosity and outcome-focused attitudes

Higher interest was associated with a stronger focus on potential positive outcomes,  $pr = 0.176, t(395) = 3.55, p < .001$ , and a weaker focus on potential negative outcomes,  $pr = -0.209, t(395) = 4.24, p < .001$ . Results support our prediction that higher interest is related to more positive outcome-focused attitudes towards uncertainty (H<sub>3</sub>). Higher deprivation was associated with the opposite – a stronger focus on potential negative outcomes,  $pr = 0.303, t(395) = 6.32, p < .001$ , and a weaker focus on potential positive outcomes,  $pr = -0.206, t(395) = 4.18, p < .001$ . Findings support the hypothesis that higher deprivation is related to more negative outcome-focused attitudes towards uncertainty (H<sub>4</sub>). Due to all correlations pairs between interest and

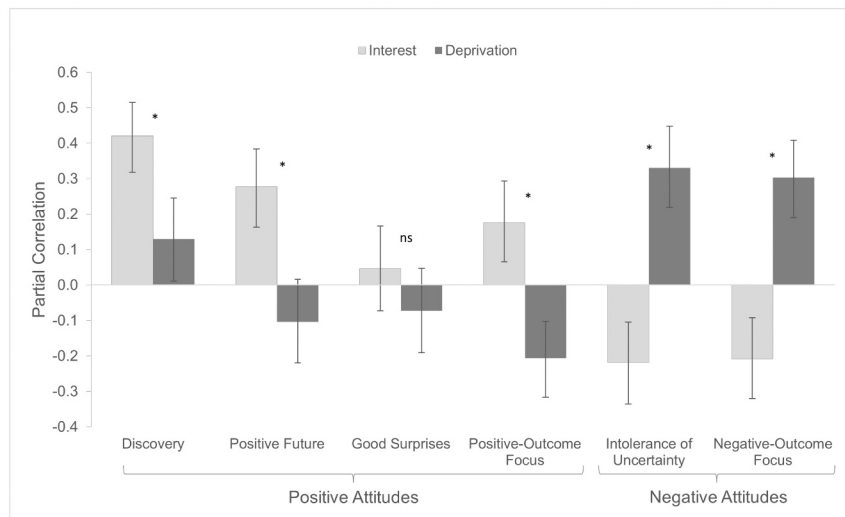


Fig. 1. Partial correlations of interest and deprivation with key uncertainty attitudes.

Note. Error bars are confidence intervals with a 98.3 % confidence level (alpha-corrected) based on Fisher's Z transform.

Asterisks (\*) indicate a significant difference between the correlations of interest and deprivation with the given uncertainty attitude,  $p < .017$ .

deprivation being significant and in opposite directions, chi-squared tests for significant differences were not needed.

Results also revealed that deprivation was moderately positively correlated with the tendency to generate and evaluate potential outcomes,  $pr = 0.277$ ,  $t(395) = 5.73$ ,  $p < .001$ , whereas interest was not significantly associated with this tendency,  $pr = -0.011$ ,  $t(395) = 0.22$ ,  $p = .825$ . Effect sizes for these relationships significantly differed,  $\chi^2_1 = 12.12$ ,  $p < .001$ . Findings suggest that becoming preoccupied with imagining possibilities is related to higher deprivation and not higher interest.

### 3. Discussion

The present study examined the connections between interest and deprivation and a variety of attitudes towards uncertainty, including attitudes towards how it feels to be uncertain (process-focused attitudes) and one's approach to evaluating possibilities (outcome-focused attitudes). We found that although interest and deprivation are both desires to reduce uncertainty (desires to learn), they differ markedly in their associated attitudes towards uncertainty, with interest linked to more positive process- and outcome-focused attitudes and deprivation linked to more negative process- and outcome-focused attitudes.

Our findings are consistent with Litman's (2010) and Lauriola et al.'s (2015) initial findings that interest is linked to a higher tolerance of uncertainty and positive outcome expectancies whereas deprivation is linked to a higher intolerance of uncertainty and negative outcome expectancies. Crucially, our results develop and extend this research in two ways. Firstly, we strengthened these past findings by replicating results in a larger, more representative sample. Secondly, by using a wider variety of measures of attitudes towards uncertainty, we provided evidence that interest and deprivation are linked to both process- and outcome-focused attitudes. This level of detail allowed us to test four hypotheses proposed by curiosity theorists which refer specifically to process- and outcome-focused attitudes.

Our findings supported these hypotheses, providing deeper insights into how interest and deprivation may motivate and reinforce learning behaviour. Past research has compared interest to positive reinforcement (since learning is rewarded with pleasure) and compared deprivation to negative reinforcement (since learning is rewarded with relief from discomfort; Litman, 2010). However, the specific sources of pleasure and discomfort through which interest and deprivation reinforce learning have remained unclear. Our findings suggest that interest may

involve at least two sources of pleasure – enjoyment from the process of uncertainty (e.g., having an unknown to wonder and speculate about) and enjoyment from the excited anticipation of learning something positive (e.g., new information that is helpful, interesting, or amusing). Similarly, findings suggest that deprivation may involve at least two sources of displeasure – discomfort from the process of uncertainty (e.g., the feeling of not-knowing) and tension caused by the apprehension of learning something negative. These sources of discomfort may then motivate learning as a means to either (a) reduce uncomfortable uncertainty or (b) investigate whether the negative possibility is true in order to feel prepared (if true) or reassured (if false). However, the present study observed only correlations between interest/deprivation and these sources of pleasure/discomfort. There would be value in further exploring these reinforcement processes using behavioral and/or experimental methods.

Our results also have broader implications for the interest-deprivation model by suggesting that interest or deprivation is a stronger motivation to learn in different uncertainty contexts. Our findings suggest that interest involves a focus on potential gains from learning (e.g., positive affect, positive discoveries) whereas deprivation involves a focus on the potential losses if the information remains missing (e.g., prolonged negative affect, potential negative outcomes). Thus, interest may be a more powerful motivation to learn when the potential gains of resolving uncertainty are more salient (e.g., learning new skills, discovering something entertaining) whereas deprivation may be more powerful when potential losses from failing to learn are more salient (e.g., failing an exam, not knowing how to solve an important problem). Previously, both Litman et al. (2005) and Loewenstein (1994) have theorised that deprivation reactions are typically more intense than interest reactions, and our findings suggest this may be explained by prospect theory's concept of loss aversion (Kahneman & Tversky, 1979) – that people feel losses more strongly than equivalent gains. That is, in situations where a person regards the potential gains and losses in the pursuit of some knowledge as equivalent in magnitude, a person experiencing deprivation is likely to feel more intensely curious than a person experiencing interest because potential losses are likely to be felt more strongly than potential gains.

Our results also add to the growing body of evidence suggesting that different types of curiosity are associated with different – and often opposite – attitudes and reactions to the unknown. This is significant because despite ongoing research and some empirical evidence to the contrary (i.e., Lauriola et al., 2015; Litman, 2010), many scholars and

clinicians continue to assume that a high tolerance of uncertainty is intrinsic to curiosity (e.g., Brewer & Roy, 2021; Kashdan et al., 2009, 2018). This assumption has not only influenced how some researchers measure and operationalise curiosity (e.g., Kashdan et al., 2009) but also has led to the development of clinical interventions for anxiety (e.g., Brewer and Roy, 2021) that focus on boosting curiosity to reduce intolerance of uncertainty (a known symptom of anxiety; Carleton, 2016). Our results suggest that this assumption is likely true for interest, but not for deprivation. Our findings highlight that curiosity can also involve high levels of discomfort with uncertainty and apprehension about what one might discover when it takes the form of deprivation rather than interest.

Another assumption that our findings provide new insight into is the commonly held belief that curious people may have a negative attitude towards secrecy because it is a barrier to learning. Scholars have expressed concern that high curiosity may tempt asocial behaviour such as violating another's privacy for the sake of learning (Akhtar, 2018) or encourage harmful behaviour such as seeking out painful or unpleasant experiences only to satisfy their curiosity (Oosterwijk, 2017). However, we observed no significant associations between interest or deprivation and one's attitude towards privacy or the existence "bad" information worth keeping unknown. This suggests that even highly curious people can restrain their curiosity when it comes to information perceived as private or bad to know. This finding suggests that although disrespecting privacy and the desire to learn harmful or forbidden information may be curiosity-led, these behaviours are likely influenced by other psychological factors and sociocultural norms rather than being driven by curiosity alone. However, it remains possible that curiosity tempts these behaviours without altering one's attitude towards performing them. For example, empirical evidence suggest that high interest- and deprivation-scorers tend to gossip more despite having more negative attitudes towards gossiping (Litman & Pezzo, 2007).

Because our study is correlational and cross-sectional, we cannot ascertain whether the causal relations between curiosity and uncertainty attitudes are uni- or bi-directional. There are plausibility arguments for either direction. It may be that stimulating interest or deprivation changes how one processes uncertainty, and/or that different uncertainty processes change which curiosity type is likely to manifest. Knowing whether one or both arguments are accurate can only be settled by experiments in future research.

A further avenue for future research would be to explore whether affective states influence whether interest or deprivation is aroused. This avenue is suggested by correlations between interest and attitudes related to optimism and excitement (e.g., a focus on positive outcomes, anticipating that uncertainty may lead to pleasure) and correlations between deprivation and attitudes related to worry and stress (e.g., a focus on negative outcomes, a preoccupation with imagining and evaluating possibilities, discomfort in uncertain situations). This idea suggests mood-induction experiments to investigate whether a positive mood while curious induces interest whereas a negative mood while curious induces deprivation.

#### CRedit authorship contribution statement

William Malcolm Whitecross: Writing – original draft (lead), conceptualisation (lead), methodology (lead), formal analysis (lead), writing – review & editing (equal). Michael Smithson: Writing – original draft (supporting), supervision, conceptualisation (supporting), methodology (supporting), formal analysis (supporting), funding acquisition, writing – review & editing (equal).

#### Funding

This work was supported by an Australian Research Council Discovery Grant (DP200100513).

#### Declaration of competing interest

None.

#### Data availability

I have shared links to the data and code in Appendix A.

#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.paid.2023.112210>.

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