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Thinking beyond boundaries: A growth theory of interest enhances integrative thinking that bridges the arts and sciences

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ABSTRACT

Innovations often arise when people bridge seemingly disparate areas of knowledge, such as the arts and sciences. What leads people to make connections that others might miss? We examined the role of implicit theories of interest—the belief that interests are relatively fixed (a *fixed theory of interest*) or developed (a *growth theory of interest*) among people with established interests either in the area of arts or sciences. A stronger growth theory predicted that participants spontaneously noticed more stimuli from the area outside their interests (Studies 2 and 3) and generated better integrative ideas (Study 1). Furthermore, they were more likely to generate ideas that bridged the arts and sciences (Study 2), which was also found after inducing fixed or growth theories, establishing causality (Study 3). Finally,perceived utility of the outside area mediated this relation (Study 4). These results suggest that a growth theory may be important for integrative thinking and innovation across traditional disciplinary boundaries.

> *[T]echnology alone is not enough—it's technology married with liberal arts, married with the humanities, that yields us the result that make our heart sing.* – Steve Jobs (2011).

Some of the most revolutionary innovations and insights have come from people and organizations who saw connections among seemingly disparate fields. Steve Jobs, co-founder of Apple, understood that in order to make computers a fixture of daily life, they had to have a human element: engaging design, visual appeal, and a user-friendly interface. He saw that science and technology were naturally complemented and enhanced by the arts and humanities. Others, such as groundbreaking architects like Zaha Hadid, Kazuyo Sejima, and Frank Gehry, integrated art, engineering, and mathematics to construct unique and inspiring structures. Innovative companies like TOMS Shoes, Impossible Foods, and Tesla have created products and technologies that address important social and environmental problems. Each of these innovators saw connections among seemingly disparate fields where others saw none.

What mindset contributes to this type of integrative thinking? To answer this question, we considered the beliefs people hold about the nature of interest, as interest can intrinsically motivate people to learn about new topics and fields (see Fredrickson, 1998; O'Keefe & Harackiewicz, 2017; Renninger & Hidi, 2015; Silvia, 2006). If people are open to the possibility that they could experience interest, and potentially see some value, in topics outside of their well-established interests, they may be more likely to explore those outside areas and see how they connect with their established interests. Indeed, highly integrative and innovative thinkers are those who see connections among different topics, which they combine and reorganize into new ideas (see Barron & Harrington, 1981; Mumford & Gustafson, 1988). Yet, too often people limit themselves to their well-established interests because they implicitly believe that interests are dispositional and relatively unchanging (a *fixed theory of interest*). These people may reason, "If I have already 'found' my interests, then there is no use in exploring new areas." Consequently, a fixed theory can inhibit people from being open to the possibility of developing interest in areas that fall outside of their existing interests (O'Keefe, Dweck, & Walton, 2018a). Such people might miss out on opportunities to learn from these different fields. By contrast, if interest is believed to be developed (a *growth theory of interest*), one may be more open to new or different areas, which may heighten their attention to relevant information from those areas, and potentially enable them to see how that information connects to their existing, well-established interests and knowledge.

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Across four laboratory studies, we tested the hypothesis that a growth theory of interest, as compared to fixed theory, promotes aspects of *integrative thinking*—a tendency to see substantive connections among seemingly disparate areas of knowledge (e.g., Martin, 2009). We recruited people with well-established interests in either the arts or the sciences (not both or neither), and we either assessed or experimentally induced implicit theories of interest. Then, we examined whether participants would spontaneously attend to stimuli outside of their well-established interest area, and whether they would show a greater tendency and ability to integrate the arts and sciences. With these studies, we take the first step in examining a potentially important mindset contributing to integrative thinking, with implications for how organizations can promote innovation.

1. Theoretical background

1.1. Implicit theories of interest

People tend to endorse one of two ideas about the nature of interest (O'Keefe, Dweck, & Walton, 2018a). Those with a fixed theory of interest tend to believe that interests are inherent to the self and relatively unchanging. Someone with this theory might think, "I'm an 'arts person,' and I'll never find the sciences interesting." By contrast, those with a growth theory of interest tend to believe that interests can be developed. With this view, someone might think, "I'm an arts person, but I'm open to exploring the sciences as well."

Like other belief systems (see Molden & Dweck, 2006), a theory of interest is a lens through which people interpret their experiences, and these beliefs have important hidden implications. Believing that interests are inherent and fixed suggests that, if one has already 'found' their interest, then there is little need to explore elsewhere. By contrast, believing interests can be developed suggests that, even if one has strong interests in one area, it does not preclude the development of new interests in other areas.

These implications were examined by O'Keefe, Dweck, and Walton (2018a). In one study, they recruited undergraduates with a well-established interest in the arts or in the sciences, and later measured the degree to which the undergraduates endorsed a fixed or growth theory of interest. Participants were then given two real academic journal articles to read. One was on a topic from the arts and the other was on a topic from the sciences. After reading each one, participants rated their interest in the article's topic. Not surprisingly, nearly everyone was interested in the article topic that matched their well-established area of interest. Those with a stronger growth theory, however, expressed more interest in the mismatching article. In other words, they were more open to the topic outside of their pre-existing academic interests.

These findings were replicated across multiple studies (O'Keefe, Dweck, & Walton, 2018a). Importantly, the studies also ruled out the possibility that the effects were instead driven by the strength of participants' pre-existing interest in the arts and the sciences, their openness to experience (measured as a personality trait), and their implicit theory of intelligence (i.e., the belief that intellectual abilities are either relatively fixed or developable). Thus, implicit theories of interest were shown to be distinct from these potentially related constructs. Furthermore, a study in which the researchers experimentally induced participants to hold either a fixed or growth theory of interest established that the effects were causal. Taken together, these studies provided reliable evidence that a growth theory of interest leads people to be more open and receptive to new interest areas as compared to a fixed theory.

1.2. Implicit theories of interest and integrative thinking

In the present research, we examined integrative thinking, operationalized as thought processes that bridge what might be viewed as disparate areas—the arts and sciences. In what ways might a growth theory of interest relate to integrative thinking? One way concerns the basic process of attention. Because those with a growth theory tend to be more open to different areas, their attention might be more readily drawn to information from those new or different areas, compared to people with a fixed theory. For example, an employee with a fixed theory whose interests are primarily in technology might naturally notice flyers at the office advertising workshops on computer programming, but fail to notice flyers advertising workshops focused on visual design. By contrast, a similar employee with a growth theory might notice the programming flyers, but also have their attention drawn to the visual design flyers.

Indeed, research has demonstrated a link between interest and attention (see Hidi, 1990; O'Keefe, Horberg, & Plante, 2017). When people encounter information that potentially fills a gap in knowledge—and potentially relates to their interests—their attention heightens their focus on this information (Silvia, 2006; 2017). This process can even occur automatically. For example, people are better able to complete a second, unrelated cognitive task while reading text that is interesting as compared to uninteresting (McDaniel, Waddill, Finstad, & Bourg, 2000; Shirley & Reynolds, 1988). Importantly, Shirley and Reynolds (1988) also found that interesting (vs. uninteresting) text was later recalled more accurately. Therefore, by causing increased openness to new or different areas of interest, a growth theory might also draw people's attention to stimuli outside of their well-established interests, as compared to a fixed theory.

A second way a growth theory of interest might lead to integrative thinking is by enabling people to perceive and draw substantive connections between their well-established areas of interest and outside areas. Why? Interest can increase learning (see O'Keefe & Harackiewicz, 2017; Renninger & Hidi, 2015; Silvia, 2006 for reviews). Research has shown that interest is associated with deeper processing of new information (Schiefele & Krapp, 1996), increased task performance (e.g., O'Keefe & Linnenbrink-Garcia, 2014), and higher course grades (e.g., Harackiewicz et al., 2008; Hulleman & Harackiewicz, 2009). If people are more open to new or different areas, they are more likely to have their interest piqued and to want to learn about the new area (O'Keefe, Dweck, & Walton, 2018a). As such, one is more likely to see substantive connections between what they already know and what they learn in a different area. Therefore, as compared to people with a fixed theory, those with a growth theory should be more likely to draw connections among seemingly disparate content areas.

This idea builds on the 'foundation' view of creativity (e.g., Weisberg, 1999), which posits a positive association between knowledge and creativity. That is, people must first have a foundation of knowledge, which then enables them to reason or create beyond that knowledge (e.g., Weisberg, 2015). Therefore, someone holding a growth theory whose interests are primarily in the arts might be more likely to also explore the sciences, meanwhile deepening their knowledge and understanding of the area. By deepening their knowledge in the sciences, they may become more likely to see connections between the arts and sciences.

Recent research is consistent with the claim that a growth theory promotes seeing connections between the arts and sciences. O'Keefe, Dweck, and Walton (2018a) recruited undergraduates whose well-established interests were either in the arts or in the sciences and measured their theory of interest. In a lab session conducted weeks later, participants reported the extent to which they perceived the arts and the sciences to overlap. Each of five scale points showed two circles—one representing the arts and the other representing the sciences—that increasingly overlapped. At one extreme, the circles did not overlap, and at the other extreme, the circles were nearly completely overlapping. Those with a stronger growth theory tended to report that the two areas were more overlapping than those with a stronger fixed theory. This was true even when controlling for the strength of their interest in the arts and the sciences, as well as their general openness to experience.

In summary, there is evidence to suggest that those with a growth theory of interest will be relatively more likely to engage in integrative thinking by attending to stimuli from outside of their well-established interest area, and by effectively seeing and forming connections between the arts and sciences.

2. Overview of the present research

Across four laboratory studies, we examined the role of a growth (as compared to a fixed) theory of interest in integrative thinking. We recruited undergraduates (Studies 1–3) and non-student adults (Study 4) whose well-established interests were either in the arts/humanities (henceforth abbreviated as the "arts") or the sciences/technology (henceforth abbreviated as the "sciences"), and we either measured their implicit theory of interest (Studies 1, 2, and 4) or induced them to hold a fixed or growth theory (Study 3). We then examined three indicators of integrative thinking. First, when explicitly instructing participants to integrate the arts and sciences, we examined the quality of the ideas they generated—in other words, their ability to integrate the two areas. Second, we examined their tendency to spontaneously notice ambient stimuli (i.e., books, pictures, objects, and words) from outside of their well-established interest area. Finally, we examined their tendency to spontaneously generate integrative solutions that bridged the arts and sciences when *not* prompted to do so. This assessment was important to examine because, although people can effectively integrate information within one particular area (e.g., someone whose well-established interests are in the sciences might integrate chemistry with engineering resulting in "chemical engineering"), they would be limiting their scope to just one area (e.g., the sciences). Instead, for this final indicator, we were most interested in whether those with a growth theory would transcend that traditional academic divide by integrating the outside area with their well-established interest area (e.g., someone whose well-established interests are in the sciences who integrates math with linguistics, yielding "computational linguistics"). Doing so would demonstrate a relatively stronger tendency to bridge the arts and sciences. Furthermore, to better understand the process by which those with a growth theory might integrate by drawing from outside of their well-established interests, we examined the mediating role of the perceived usefulness of the outside area. We focus on usefulness given our theorizing that a growth theory of interest opens people to the possibility of seeing some value (or utility) in outside areas, despite not having an established interest in them.

3. Study 1

The purpose of Study 1 was to perform an initial test of our hypothesis that a stronger growth theory is associated with integrative thinking; specifically, a better ability to integrate a well-established interest area with an outside area. Undergraduates with a well-established interest in either the arts or sciences were asked to imagine that they were a curator of a museum and to draw from the area outside of that interest (arts or sciences) to create new exhibits. Independent raters then coded the quality of their ideas. We hypothesized that a stronger growth theory of interest would predict higher quality ideas, thus demonstrating their better ability at integrating an outside area with their well-established interests (and in doing so, demonstrating an increased ability to integrate the arts and sciences).

3.1. Method

3.1.1. Participants

Two-hundred-ninety-four undergraduates from an internationally diverse university in Singapore completed a prescreen, 188 of whom were eligible to participate. Due to a slow uptake, the study ran across two semesters and yielded 68 participants. Four did not provide codable responses, and were therefore omitted. The remaining 64 (37 female, 25 male, 2 undisclosed) had a mean age of 22.31 ($SD = 2.80$). They were each paid $7 SGD.

3.1.2. Procedure

Participants completed an online prescreen, which had two purposes. First, it assessed their implicit theory of interest separately from their participation in the laboratory session in order to conceal its connection to the experimental tasks. Second, it assessed their *academic interest identity*—the extent to which participants saw themselves as a person oriented toward the arts or toward the sciences. This was used to determine their eligibility and to identify whether their well-established interest area was in the arts or the sciences. Only those who held one identity and not the other (i.e., a well-established interest in either the arts or the sciences) received a code that enabled them to sign up for the study.

At a later date, participants were run individually in a laboratory. The entire session took place on a desktop computer. After reading a welcome screen, they began the integration task, which involved generating ideas for museum exhibits that integrated the area outside of their interest identity (arts or sciences) with the area in which they held an interest identity (arts or sciences). Afterward, participants completed a series of other tasks that were being piloted to test different hypotheses. Finally, they completed basic demographics. The entire session took 30 minutes or less.

3.2. Measures and materials

See Table 1 for descriptive statistics and correlations of all measures.

3.2.1. Theories of interest scale

During the prescreen, potential participants completed a measure that assessed the degree to which they endorsed a fixed or growth theory of interest (see O'Keefe, Dweck, & Walton, 2018a). The scale included four items for which participants indicated their level of agreement on a 6-point scale (1 = *strongly disagree*, 6 = *strongly agree*): "To be honest, your core interests will remain your core interests. They won't really change," "No matter how central your interests are to you, they can change substantially," "You can be exposed to new things, but your core interests won't really change," and "Even if you have very strong interests, they can change dramatically." Fixed-phrased items were reverse-coded and a mean composite was calculated with higher values indicating a stronger growth theory ($\alpha = 0.82$).

3.2.2. Interest identity

During the prescreen, potential participants reported the degree to which they viewed themselves as a person with interests oriented toward the arts ("I am an Arts/Humanities-oriented person") and the sciences ("I am a Science/Technology-oriented person") on a 6-point scale (1 = *strongly disagree*, 6 = *strongly agree*). Participants who agreed with one statement (responses of *4*, *5*, or *6*) and disagreed with the other (responses of *1*, *2*, or *3*) were eligible for the study, such that they had one well-established area of interest, with the other being outside of that area. In the final sample, there were 26 participants with an arts interest identity and 38 with a sciences interest identity.

Although these items aided our selection procedure, consistent with prior research (O'Keefe, Dweck, & Walton, 2018a), they were also used as covariates, along with their interaction, given that our main task assessed the integration of the two areas. We sought to rule out an alternative explanation that participants' interest identities, either individually or multiplicatively, would predict higher scores on the integration task. By including them as covariates, we tested the hypothesis that theories of interest predict our central outcome above and beyond participants' interest identities.

3.2.3. Museum integration task and measure

Participants with an arts interest identity read the following instructions: "Imagine you are the chief curator of an Arts/Humanities museum. In the space below, list all of the ways, if any, you could draw from Science/Technology fields to create your exhibits." Those with a

Table 1
Descriptive statistics and correlations (Study 1).

Variables	*M*	*SD*	95% CI LL	95% CI UL	1.	2.	3.	4.	5.
1. Theory of interest	3.27	0.97	3.03	3.51	–				
2. Sciences interest identity	3.89	1.30	3.57	4.21	−0.05	–			
3. Arts interest identity	3.52	1.27	3.20	3.83	−0.10	−0.84**	–		
4. Number of ideas (fluency)	2.77	1.21	2.47	3.08	0.01	−0.11	0.07	–	
5. Quality of ideas	4.24	1.11	3.96	4.52	0.29*	−0.14	−0.05	0.18	–

Note. M = Mean. *SD* = Standard Deviation. CI = Confidence interval of the mean. LL = Lower level. UL = Upper level. $^*p < 0.05$, $^{**}p < 0.01$. Higher theory-of-interest scores indicate a stronger growth theory.

sciences interest identity read the following instructions: "Imagine you are the chief curator of a Science/Technology museum. In the space below, list all of the ways, if any, you could draw from Arts/Humanities fields to create your exhibits." All participants were asked to write each idea on a new line and were informed that they would have 3 minutes to complete the task, after which the computer program would automatically advance to the next screen.

Two research assistants (who were blind to participants' implicit theory of interest, interest identity, and our hypothesis) coded the ideas generated. Because participants varied with regard to how many responses they generated, the research assistants coded the quality of the participants' ideas as a whole on a 7-point scale (1 = *very bad*, 4 = *neither good nor bad*, 7 = *very good*; rating individual responses and either summing or averaging the ratings would have potentially misrepresented their ability). In judging the overall quality, they were instructed to consider how useful the ideas were, their feasibility, and whether they were appropriate for a museum setting in terms of their educational value. To train research assistants, in meetings, we selected several responses at random and discussed how each should be rated given these parameters. Research assistants then coded all responses independently. Inter-rater reliability was good (ICC = 0.83), suggesting there was agreement on overall quality. For example, one participant coded as giving a high-quality response compellingly explained how they would draw upon literature, history, economics, psychology, and geography to create exhibits for a science museum. The participant's ideas were useful as educational tools, their implementation was feasible, and they were appropriate for the type of museum they were charged to curate. A participant coded as giving a low-quality response suggested using basic audio/visual elements (e.g., speakers and digital displays) to create an exhibit in an arts museum. Although feasible, the response did not demonstrate or elaborate on its educational usefulness. Research assistants also coded the total number of ideas generated (ICC = 0.91).

3.3. Results and discussion

All tests reported here and in the remaining studies are two-tailed, and all confidence intervals are at the 95% level.

As hypothesized, undergraduates with a stronger growth theory of interest tended to generate ideas that were judged to be of relatively higher quality, $b = 0.33$, $\beta = 0.29$, $t(62) = 2.34$, $p = 0.022$, [0.048, 0.608] (see Fig. 1). The effect held, $b = 0.30$, $\beta = 0.26$, $t(59) = 2.05$, $p = 0.045$, [0.007, 0.598], when controlling for the strength of participants' interest identities in arts, in sciences, and their interaction, $ts < 1$. Therefore, as in past research (O'Keefe, Dweck, & Walton, 2018a), the effect was driven by theories of interest, not the intensity of participants' interest or disinterest in the arts and sciences.

Furthermore, participants' theory of interest did not predict the number of ideas they generated, $b = 0.02$, $\beta = 0.01$, $t(62) = 0.11$, $p = 0.912$, [−0.300, 0.335], and the overall quality of ideas was not predicted by the number of ideas generated, $b = 0.17$, $\beta = 0.18$, $t(62) = 1.44$, $p = 0.154$, [−0.064, 0.396]. These additional results illustrate that a stronger growth theory of interest specifically predicted the overall quality of ideas, not the quantity of ideas, and that the quantity of ideas did not influence coders' ratings of quality.

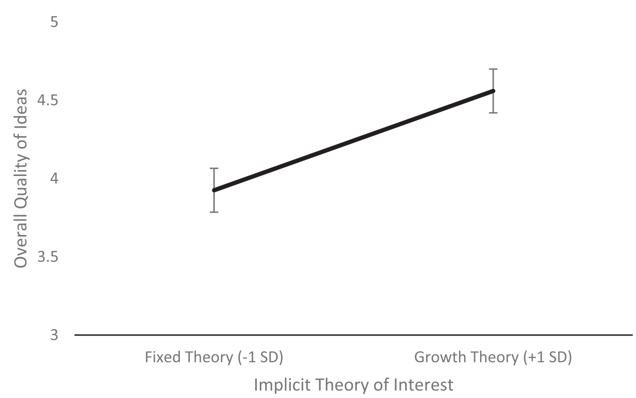

Fig. 1. *Mean quality of integrative ideas generated by participants as judged by coders (Study 1). Note.* Fixed and growth theories of interest are plotted at 1 standard deviation below and above the mean, respectively. The rating scale ranged from 1 to 7. Error bars represent standard errors.

To summarize, our results supported the hypothesis that a growth theory of interest predicts a greater ability to integrate an outside area with one's well-established interest area, bridging the arts and sciences. A shortcoming of this study, however, was the relatively small sample size. A *post hoc* analysis found that our observed effect had statistical power (1-β) of 0.76, falling short of the conventional 0.80. In the remaining studies, we sought to conceptually replicate and extend these findings using different methodologies and larger sample sizes.

4. Study 2

The present study built on Study 1 in several ways. First, whereas Study 1 explicitly instructed participants to integrate the arts and sciences in order to assess their *ability* to do so, in Study 2 we investigated people's spontaneous, unprompted *tendency* to integrate the two areas. If supported, the findings would demonstrate that people with a stronger growth theory have a greater proclivity for integrative thinking that extends beyond their well-established interests, not only greater ability when required to do so. To this end, we administered a new task in which participants generated ideas that integrated various common arts and sciences academic fields. We hypothesized that people with a stronger growth theory would be more likely to integrate arts fields with sciences fields (rather than fields within only one area). Similar to Study 1, we also coded the overall quality of their ideas.

Second, Study 2 examined an additional indicator of integrative thinking: the degree to which people spontaneously attend to information from outside of their interest identity. We hypothesized that people with a stronger growth theory would naturally be more attentive to ambient information from outside of their interest identity.

Finally, we examined several secondary hypotheses regarding the relation between a stronger growth theory and overall integrative ability (regardless of whether it was within the same area or across areas), as well as several indicators of divergent and creative thinking. Although interesting, they are secondary because they do not test our central claim about bridging the arts and sciences.

4.1. Method

The method, materials, and hypotheses were preregistered and can be viewed at osf.io/y7ueg.

4.1.1. Participants

In Study 1, the relation between theories of interest and integration ability was $r = 0.285$. Given that the outcomes investigated in the present study were different than Study 1, we used a more conservative effect size of $r = 0.25$ for our sample size calculation. With $1\text{-}\beta = 0.80$ and $\alpha = 0.05$, the minimum sample size was 97 for a one-tailed test of a directional hypothesis (for consistency, we report results as two-tailed). Three-hundred-eighty-three undergraduates from an internationally diverse university in Singapore completed the prescreen, 108 of whom qualified for the study and were enrolled. We oversampled in case of data loss. Indeed, seven participants did not follow instructions on the main tasks or did not provide codable responses, leaving 101 participants (72 females). The mean age of the final sample was 21.27 (SD = 1.88). They each received $7 SGD.

4.1.2. Procedure

Potential participants completed a prescreen to determine their eligibility. They first completed the theories-of-interest scale, and then the assessment of their academic interest identities. As in Study 1, only those who reported having one interest identity (arts or sciences), were eligible. Eligible participants then received a code to sign up for an in-lab study to take place sometime at least one week later. Participants were run individually.

Upon arriving at the lab, participants were greeted by the experimenter. Under the pretense that she required more time to set up the computer for the study, the experimenter requested that the participant wait in a different room at a desk in what was ostensibly her colleague's cubicle. In fact, the cubicle was staged to look like a workspace, and was arranged with an equal number of arts and sciences stimuli. These included 20 books (10 each belonging to arts and sciences), two objects (a small bust of Plato and a model of a molecule), and four posters (paintings by Pablo Picasso and Georges Seurat, and charts of the periodic table and the solar system). Arts and sciences stimuli were distributed evenly throughout the cubicle, and all stimuli were situated to be in participants' field of vision when seated at the desk. The experimenter placed the participant's belongings (e.g., phone, backpack) outside of the cubicle to avoid distractions that might interfere with participants' attention (or inattention) to the stimuli. After precisely 3 minutes, the experimenter returned and told participants that the study was ready and led them to the room where the remainder of the study was conducted.

Prompted by computer instructions, participants first completed a filler task designed to place a time gap between sitting in the cubicle and the free-recall task to follow. Doing so provided a more rigorous test of participants' free-recall of stimuli rather than relying on a recency effect. For the filler task, participants crossed out vowels on a sheet of paper containing five paragraphs of text. The text was meaningless in order to avoid priming participants with other constructs (see Supplement for materials).

Next, participants returned to the computer and began the free-recall task for which they were asked to list the books, pictures, and other objects they remembered from the cubicle, and to provide details for each. After the recall task, participants completed a brief secondary, less rigorous assessment of attention (the task and its findings are discussed in the supplement).

In the next phase of the experiment, participants completed the integration task, which assessed their spontaneous tendency to bridge the arts and sciences when generating ideas for new academic majors for their university. Finally, participants completed basic demographics.

4.2. Measures and materials

See Table 2 for descriptive statistics and correlations of all measures.

4.2.1. Theories of interest scale

Same as in Study 1 ($\alpha = 0.87$).

4.2.2. Interest identity

Same as in Study 1. There were 55 participants with an arts interest identity and 46 with a sciences interest identity.

4.2.3. Cubicle free-recall task and measure

For the free-recall task, participants read the following instructions:

> Prior to taking this survey, you were asked to wait at a desk that had a variety of books, pictures, and objects. These spanned multiple academic disciplines. In bullet points, please list the books, pictures, and other objects you can recall from the desk area, and provide details for each. Please list as many or as few as you can remember.

The number of items participants could freely recall was used to measure their spontaneous attention to stimuli that matched and mismatched their interest identity. Research assistants—different than those from Study 1—who were blind to participants' theory of interest, interest identity, and our hypotheses, independently recorded the number of correctly-recalled items for arts (ICC = 0.99) and sciences (ICC = 0.98) items and their scores were averaged. Overall, participants correctly recalled an average of 5.06 items (SD = 2.73; 19.5% of the total).

4.2.4. College majors integration task and measure

Participants' spontaneous tendency to integrate the arts and sciences was assessed with a task in which they combined existing academic programs at their university to create new majors. The instructions read:

> Your task is to create new academic majors that could be implemented at [*university*]. The majors you create, however, should combine existing programs offered at the university. Please take a moment to look over the abridged list of programs below, which are offered at [*university*].

Participants were provided with a list of 18 common majors, listed in alphabetical order, half of which were in the arts (e.g., literature, history, theatre studies) and half in the sciences (e.g., physics, engineering, computer science). They were asked to form as few or as many new academic majors as they wished by combining two or more of these existing majors and to give a brief rationale for each. They were told they could take as much time as they wished. Critically, participants were not told that their ideas must combine arts fields with science fields (as opposed to combining fields from only one area)—that decision was left up to them in order to assess their natural, spontaneous tendency. Thus, generating ideas that bridged arts fields with science fields would indicate a natural tendency to integrate an outside area with their well-established interest area.

To this end, participants' responses were independently coded by the research assistants for the overall degree to which the majors that participants generated integrated the arts and sciences (1 = *very little or not at all integrated*, 4 = *somewhat integrated*, 7 = *very integrated*). The approach to training research assistants was the same as in Study 1. Inter-rater reliability was good (ICC = 0.89) and their codes were averaged. We used an overall assessment of arts-sciences integration across participants' entire response so that coders could consider the extent to which participants bridged the two areas, along with the number of ideas that included bridging. For example, a participant who generates one good idea that bridges the two areas should receive the

Table 2
Descriptive statistics and correlations (Study 2).

Variables	*M*	*SD*	95% CI LL	95% CI UL	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Theory of interest	3.28	1.00	3.08	3.48	–									
2. Sciences interest identity	3.61	1.44	3.33	3.90	−0.11	–								
3. Arts interest identity	3.72	1.37	3.45	3.99	0.10	−0.83**	–							
4. Correct recall of matching items	2.96	1.87	2.59	3.33	−0.07	0.20*	−0.08	–						
5. Correct recall of mismatching items	2.10	1.53	1.80	2.41	0.25*	−0.39**	0.49**	0.28**	–					
6. Fluency	5.01	2.81	4.46	5.56	−0.04	−0.21*	0.26**	0.05	0.26**	–				
7. Quality of ideas	3.59	1.12	3.37	3.82	0.21*	−0.10	0.10	0.25*	0.27**	−0.06	–			
8. Integration of arts and sciences	2.42	1.57	2.12	2.73	0.27**	0.02	0.01	0.23*	0.16	0.13	0.45**	–		
9. Elaboration	0.85	0.43	0.77	0.94	0.23*	−0.03	−0.02	0.17†	0.11	−0.32**	0.76**	0.29**	–	
10. Originality	1.35	0.94	1.17	1.54	0.17†	−0.20†	0.21*	0.10	0.11	0.04	0.28**	0.41**	0.17†	–

Note. M = Mean. *SD* = Standard Deviation. CI = Confidence interval of the mean. LL = Lower level. UL = Upper level. $^*p < 0.05$, $^{**}p < 0.01$, $^†p < 0.10$. Higher theory-of-interest scores indicate a stronger growth theory.

same arts-science integration code as a participant who generates one equally good idea that bridges the arts and sciences, but provided three additional ideas that combined fields within a single area. We also instructed the coders to consider the extent to which participants' rationales bridged the two areas, given the possibility that they might only discuss one of the areas in their rationale. Therefore, as in Study 1, summing or averaging individual ratings could have resulted in misleading scores.

An example of a response coded as highly integrative provided multiple ideas that bridged the arts and sciences (e.g., engineering and film studies, computer science and psychology, and various sciences majors with theater studies). A rationale given for one of these ideas, which combined engineering and film, read:

> Engineering provides good maths and physics foundation but does not allow students to develop their communication skills as much. Films are one of the best modes of communication there are today. By learning how to study films, it could help engineering students understand how they can market their products to other people who might not see the value in the products just from technical explanations.

A response coded as low in integration proposed multiple ideas that only combined fields within the arts. For example, one participant combined creative writing and theater studies, and art and foreign language studies.

Research assistants also coded the quality of the ideas. Although we were primarily interested in examining participants' spontaneous tendency to integrate the arts with the sciences, we were also interested in examining the quality of their ideas as a whole, regardless of whether they integrated fields across the arts and sciences or integrated fields within only one area. The stronger integration abilities of those with a stronger growth theory should theoretically apply even when forging connections among fields within the same arts or sciences areas. Therefore, those with a stronger growth theory should be more likely to generate ideas that are better overall. Judgments were based on the rationale provided, taking into consideration how coherent and useful the ideas were for a university setting (1 = *very bad/unconvincing or no rationale*, 4 = *reasonable/somewhat convincing rationale*, 7 = *very good/very convincing rationale*) and the coders' scores were averaged (ICC = 0.82).

Research assistants also coded responses on other factors not central to our main hypotheses. These included several variables related to the broader concepts of divergent and creative thinking: fluency, elaboration, and originality (see Kaufman, Russell, & Plucker, 2013 for a review and coding procedures). Fluency referred to the number of ideas generated (ICC = 0.99). Elaboration referred to the degree of detail provided in the rationale for each idea, which was rated on a 3-point scale (0 = *no detail*, 1 = *moderate detail*, 2 = *lots of detail*). A total was calculated and divided by participants' fluency score, reflecting their average elaboration per response (ICC = 0.95). Finally, originality referred to the uniqueness of each idea. Responses given by only 5% of the pool were scored as '1′; responses that were given by 1% of the pool were scored as '2.' All other responses were scored as '0′. Participants' average originality score reflected the sum of their individual scores divided by their fluency score (ICC = 0.92).

4.3. Results

4.3.1. Cubicle free-recall

A preliminary analysis showed that participants recalled more science-related items overall ($M = 3.04$, $SD = 1.61$) than arts-related items ($M = 2.02$, $SD = 1.77$), $t(100) = 5.15$, $p < 0.001$, $d = 0.60$. Furthermore, participants recalled more items overall from the area that matched than mismatched their interest identity, $t(100) = 4.19$, $p < 0.001$, $d = 0.50$.

More importantly, and in line with our hypothesis, a stronger growth theory of interest predicted the free-recall of more items from the cubicle that mismatched participants' interest identity, $b = 0.38$, $\beta = 0.25$, $t(99) = 2.54$, $p = 0.013$, [0.084, 0.679] (see Fig. 2). The effect also held, $b = 0.30$, $\beta = 0.19$, $t(96) = 2.14$, $p = 0.035$, [0.022, 0.568], while controlling for their interest identities (z-scored) in arts, $b = 0.81$, $\beta = 0.53$, $t(96) = 3.44$, $p = 0.001$, [0.343, 1.279], in sciences, $t < 1$, and their interaction,

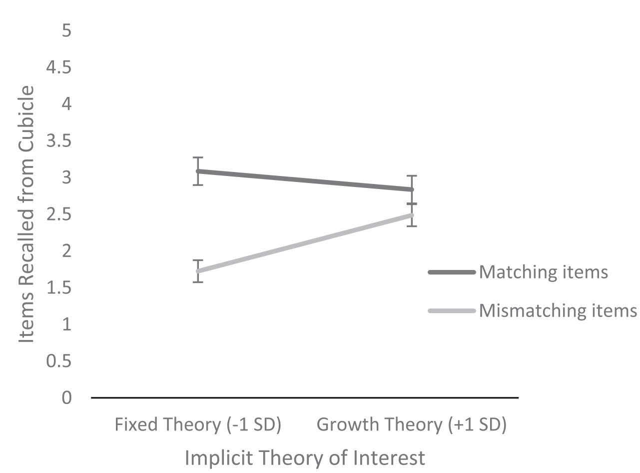

Fig. 2. *Mean number of items correctly recalled from the cubicle that matched and mismatched participants' interest identity (Study 2). Note.* Fixed and growth theories of interest are plotted at 1 standard deviation below and above the mean, respectively. Error bars represent standard errors.

$t < 1$. Also as expected, theories of interest did not predict free-recall of items that matched their interest identity, $b = -0.13$, $\beta = -0.07$, $t(99) = -0.66$, $p = 0.509$, [−0.498, 0.249].

4.3.2. College majors integration task

As hypothesized, a stronger growth theory of interest predicted ideas for new majors that more strongly integrated programs between the arts and sciences, $b = 0.42$, $\beta = 0.27$, $t(99) = 2.77$, $p = 0.007$, [0.120, 0.724] (see Fig. 3). This effect held, $b = 0.40$, $\beta = 0.25$, $t(96) = 2.50$, $p = 0.014$, [0.082, 0.715], when controlling for interest identities in arts, in sciences, and their interaction, $ts < 1$.

We then examined several secondary hypotheses. A stronger growth theory predicted that participants' ideas were of higher quality overall, $b = 0.24$, $\beta = 0.21$, $t(99) = 2.17$, $p = 0.032$, [0.021, 0.460]. The effect became marginal, $b = 0.22$, $\beta = 0.19$, $t(96) = 1.88$, $p = 0.063$, [−0.012, 0.448], when controlling for interest identities in arts, in sciences, and their interaction, $ts < 1$.

Regarding divergent and creative thinking, as expected, a stronger growth theory predicted more elaborate rationales, $b = 0.10$, $\beta = 0.23$, $t(99) = 2.35$, $p = 0.021$, [0.016, 0.185]. This effect held, $b = 0.10$, $\beta = 0.24$, $t(97) = 2.31$, $p = 0.023$, [0.015, 0.192], when controlling for interest identities in arts, in sciences, and their interaction, $ts < 1$. As in Study 1, a stronger growth theory did not predict fluency, $b = -0.12$, $\beta = -0.04$, $t(99) = -0.41$, $p = 0.682$, [−0.678, 0.445]. Originality, although not significant, trended in the predicted direction, $b = 0.16$, $\beta = 0.17$, $t(99) = 1.70$, $p = 0.092$, [−0.027, 0.344].

4.4. Discussion

Study 2 extended Study 1 by showing that a stronger growth theory of interest predicts two additional aspects of integrative thinking. Specifically, participants with a stronger growth theory were more likely to spontaneously notice and freely recall ambient items from outside of their interest identity, suggesting that this aspect of integrative thinking can emerge in basic stages of the thinking process. Moreover, heightened attention to these outside items did not come at the cost of reduced attention to items relevant to participants' well-established interest area. Additionally, participants with a stronger growth theory were more likely to spontaneously integrate programs from the arts and sciences (rather than only within one area) when generating novel ideas (i.e., new college majors). Although the ratings of arts-science integration made by coders were relatively low overall, it is striking that the predicted patterns emerged given that participants were not prompted to combine programs across the two areas. Finally, those with a stronger growth theory generated ideas that were judged to be of higher quality overall.

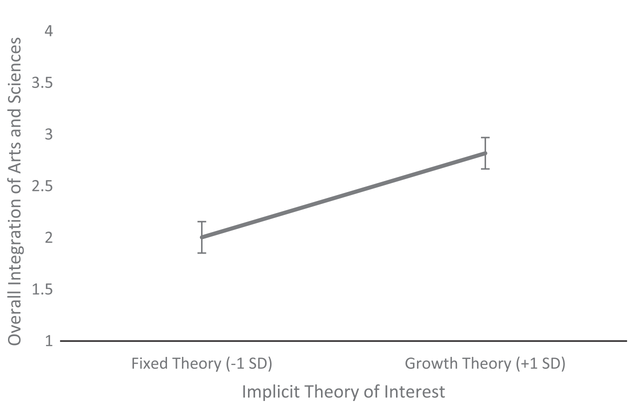

Fig. 3. *Mean degree to which the ideas generated integrated university programs from the arts and sciences as judged by coders (Study 2). Note.* Fixed and growth theories of interest are plotted at 1 standard deviation below and above the mean, respectively. The rating scale for integration ranged from 1 to 7. Error bars represent standard errors.

Taken together, Studies 1 and 2 revealed that a stronger growth theory of interest is associated with greater integrative thinking. Because participants' theory of interest was measured rather than induced, however, there remains a critical question: Does a growth (vs. fixed) theory of interest *cause* people to attend to information from outside their well-established interest area and to integrate information from outside of that area with their well-established interests?

5. Study 3

The purpose of this study was to replicate and extend Study 2 by examining the causal role of implicit theories of interest. To this end, fixed and growth theories of interest were induced rather than measured, after which participants completed the same integration task used in Study 2, followed by a new task that assessed their attention to arts and sciences stimuli. Because participants were led to temporarily hold either a fixed or growth theory of interest, rather than assessing individual differences, the new attention task was designed to require less pre-existing knowledge than the attention task in Study 2. Specifically, we designed a word search that included only well-known words relating to the arts and sciences.

We hypothesized that participants induced to hold a growth (vs. fixed) theory of interest would evince a stronger tendency to generate ideas that integrated the arts and sciences. Even if a growth theory is temporarily induced, it should make participants relatively more open to the outside area. Thus, integration should still be stronger because undergraduates' existing knowledge of different common academic areas that lie outside of their interest identity would become more accessible, and therefore readily drawn upon and connected. For similar reasons, we also hypothesized that in the word search task, those induced to hold a growth theory would more readily notice words from outside their (arts or sciences) interest identity.

5.1. Method

Our method, materials, and hypotheses were preregistered and can be viewed at osf.io/je7p9.

5.1.1. Participants

Given that we tested our hypothesis using an induction procedure for the first time, we calculated our pre-registered sample size with a small-to-medium effect size, $f^2 = 0.085$, which is commonly obtained in social psychological research (see Richard, Bond Jr, & Stokes-Zoota, 2003). With $1\text{-}\beta = 0.80$ and $\alpha = 0.05$, we pre-registered that the minimum sample size required for our primary hypotheses was 115. Three-hundred-eighty-six undergraduates from an internationally diverse university in Singapore completed the prescreen described in Study 1. One-hundred-seventy-nine qualified for the study; however, we capped enrollment at 127 (i.e., the minimum sample size of 115 plus 10% in case of data loss). Eight participants did not follow instructions or provided uncodable responses on the main tasks and were removed prior to analyses, leaving a total of 119 (67 female; $M_{age} = 21.82$, $SD_{age} = 1.79$). They were each paid $7 SGD.

5.1.2. Procedure

As in Studies 1 and 2, potential participants completed a prescreen that assessed their arts and sciences interest identities and determined their eligibility. Eligible participants who enrolled were run individually in the lab at least one week later. The study was conducted primarily on a computer during a 30-minute session. The welcome screen explained that the study consisted of verbal and cognitive tasks involving "reading comprehension, idea generation, and word recognition."

Participants first completed the theory-of-interest induction (O'Keefe, Dweck, & Walton, 2018a), which was described as the "reading comprehension" portion of the study. They were randomly assigned to receive either the fixed-theory or growth-theory materials, which involved reading a 2-page research article written for a general audience. Afterward, they completed a quiz of five multiple-choice questions, which functioned as part of the reading-comprehension cover story and as an attention check. Participants then completed two short scales regarding secondary hypotheses unrelated to our central research questions (see Supplement).

Next, participants completed the integration task described in Study 2, which was cast as the "idea generation" portion of the study. As in the previous study, they were given an abridged list of common degree programs at their university and were instructed to create new college majors by combining two or more of them.

Next, participants completed a word search task—the kind commonly found in a Sunday newspaper—which was cast as the "word recognition" portion of the study. It was used to assess cognitive accessibility of words relating to the arts and sciences; that is, how readily the words drew participants' attention. The computer prompted participants to retrieve the experimenter, who then provided the task on a sheet of paper and explained the instructions. The experimenter then gave participants 2 minutes to find as many words as they could. When the experimenter started timing, participants flipped over the paper to begin and the experimenter waited outside the room until time was up.

Finally, participants completed the theories-of-interest scale, which was used as a manipulation check, as well as basic demographics.

5.2. Measures and materials

See Tables 3 and 4 for descriptive statistics and correlations within each experimental condition.

5.2.1. Interest identity

Academic interest identity was assessed and employed to recruit participants with interest identities in the arts ($n = 42$) and sciences ($n = 77$) in the same manner as described in Study 1.

5.2.2. Theory of interest inductions and quizzes

Participants in both experimental conditions read a 2-page article (O'Keefe, Dweck, & Walton, 2018a), ostensibly published in *Education Today* (see Supplement) and written for a general audience. In the fixed-theory condition, the article summarized research suggesting that interests are inherent predispositions revealed at some point in one's life and are relatively stable thereafter. In the growth-theory condition, the article summarized research suggesting that interests can be developed and cultivated as people interact with a domain.

Afterward, participants answered five multiple-choice questions about its content. Each question included four response options, and they had up to 30 seconds to respond before automatically advancing to the next screen. For example, one question asked, "According to the article, what is true about people's core interests?" Response options included, "They are inherent and relatively stable throughout the lifespan" (correct for the fixed-theory condition) and "People's interests are developed and changeable" (correct for the growth-theory condition).

5.2.3. College majors integration task and measure

The integration task was conducted and coded identically to Study 2. Responses were coded for the overall degree to which participants integrated arts and sciences fields (ICC = 0.90). Also identical to Study 2, the responses were coded for their overall quality (ICC = 0.87), fluency (ICC = 0.99), and degree of elaboration (ICC = 0.93). Originality was not coded due to its time-intensive procedure along with its null effect in the prior study.

5.2.4. Word search task

The word search was provided on paper and consisted of a 25 × 25 grid of letters. Hidden within the grid were 10 words relating to arts fields (e.g., literature, philosophy, artist) and 10 relating to sciences fields (e.g., mathematics, physics, engineer; see Supplement for materials). Half of the arts and sciences words were presented vertically and the other half horizontally. The words were roughly matched based on frequency of use (Word Frequency Data, 2016), length, and word type (e.g., fields, professions) across the two categories. Participants were not given the list of hidden words, but were told by the experimenter that the words were six or more letters long and presented either vertically or horizontally, not diagonally or backward. These instructions were also provided at the top on the page. Two scores were calculated: the number of words found that matched and mismatched participants' interest identity.

We constructed this task because it was conceptually similar to the attention task in Study 2, yet more appropriate for use in an experiment that temporarily induced theories of interest. In the prior study, where implicit theories were measured, participants came to the lab with a history of applying their theory of interest to their experiences. Therefore, they were expected to naturally attend or not attend to the relatively nuanced ambient stimuli (e.g., Aristotle's *Nicomachean Ethics*, a book titled *Graph Theory*). Because we induced their implicit theory in the current study, they may not have come to the lab with that same degree of experience (or lack of experience) with information from the two academic areas. Therefore, we chose words that virtually any

Table 3
Descriptive Statistics and Comparisons of Fixed- vs. Growth-theory-of-Interest Conditions (Study 3).

Variable	*M*		*SD*		95% CI LL		95% CI UL		Cohen's *d* for the mean difference between fixed and growth conditions
	Fixed condition	Growth condition	Fixed condition	Growth condition	Fixed condition	Growth condition	Fixed condition	Growth condition	
1. Sciences interest identity	4.06	4.11	1.42	1.34	3.67	3.78	4.45	4.43	0.04
2. Arts interest identity	3.30	3.44	1.42	1.48	2.91	3.08	3.69	3.80	0.10
3. Integration of arts and sciences	2.18	2.78	1.30	1.68	1.82	2.37	2.54	3.19	0.40
4. Quality of ideas	3.36	3.45	1.17	1.11	3.03	3.18	3.68	3.73	0.08
5. Fluency	4.03	4.14	2.44	2.42	3.36	3.55	4.70	4.74	0.05
6. Elaboration	3.77	3.45	2.62	2.89	3.05	2.74	4.50	4.16	0.12
7. Words found that match interest identity	3.32	3.68	1.76	1.51	2.83	3.31	3.81	4.05	0.22
8. Words found that mismatch interest identity	3.09	3.68	1.48	1.53	2.69	3.31	3.50	4.06	0.39

Note. *M* = Mean. *SD* = Standard Deviation. CI = Confidence interval of the mean. LL = Lower level. UL = Upper level. *$p < 0.05$, **$p < 0.01$, †$p < 0.10$.

Table 4
Correlation matrix for fixed and growth experimental conditions (Study 3).

Variable	1.	2.	3.	4.	5.	6.	7.	8.
1. Sciences interest identity	–	−0.86*	0.17	0.11	−0.18	−0.02	0.04	0.40**
2. Arts interest identity	−0.86**	–	−0.22†	−0.20	0.10	−0.02	0.11	−0.37**
3. Integration of arts and sciences	−0.05	0.10	–	0.29*	0.16	0.14	0.12	0.10
4. Quality of ideas	0.14	0.07	0.28*	–	−0.05	0.67**	0.16	0.23†
5. Fluency	−0.01	−0.003	−0.14	0.03	–	0.48**	0.20	−0.11
6. Elaboration	−0.04	0.17	0.11	0.62*	0.63**	–	0.30*	0.15
7. Words found that matched interest identity	−0.08	0.13	−0.29*	0.08	0.09	−0.01	–	0.37**
8. Words found that mismatched interest identity	0.27*	−0.25†	−0.43**	−0.03	−0.14	−0.21	0.23†	–

Note. Correlations for the growth-theory condition appear above the diagonal; correlations for the fixed-theory condition appear below the diagonal. *$p < 0.05$, **$p < 0.01$, †$p < 0.10$.

undergraduate would have likely encountered and could recognize. By limiting the task to 2 minutes, we assessed which words were most cognitively accessible to them.

5.2.5. *Theories of interest*

Theories of interest were assessed in the same manner described in Study 1, and the scale was employed as a manipulation check ($\alpha = 0.75$).

5.3. *Results*

5.3.1. *Attention check and manipulation check*

Several analyses were conducted to assess the success of the inductions. First, we examined quiz scores as an attention check. A total score out of a possible five was calculated for the fixed-theory ($M = 3.87$, $SD = 1.07$) and growth-theory conditions ($M = 4.44$, $SD = 0.75$), which indicated that, overall, participants read and comprehended their assigned article. Although those in the fixed-theory condition did not score as well as those in the growth-theory condition, $t(117) = 3.42$, $p = 0.001$, $d = 0.62$, this difference was driven by one particularly difficult question in the fixed-theory version of the quiz that only 35% answered correctly.

Next, we analyzed theory-of-interest scores, which was assessed at the end of the study. Those in the growth-theory condition ($M = 3.90$, $SD = 0.98$) endorsed a stronger growth theory than those in the fixed-theory condition ($M = 3.01$, $SD = 0.94$), $t(117) = 5.05$, $p < 0.001$, $d = 0.93$. Furthermore, those in the growth-theory condition were significantly above the mid-point (3.5) of the scale, $t(65) = 3.34$, $p = 0.001$, whereas those in the fixed-theory condition were significantly below the mid-point, $t(52) = 3.82$, $p < 0.001$, demonstrating that, in both conditions, the inductions had successfully led them to endorse the intended implicit theory.

5.3.2. *College majors integration task*

Our focal analyses were conducted with regression, with the growth-theory condition coded as 1, and the fixed-theory condition coded as −1.

As expected, those in the growth-theory condition evinced a greater tendency to integrate the arts with the sciences, as compared to those in the fixed-theory condition, $b = 0.30$, $\beta = 0.19$, $t(117) = 2.14$, $p = 0.034$, [0.023, 0.578] (see Fig. 4). The effect of theory-of-interest condition held, $b = 0.31$, $\beta = 0.20$, $t(114) = 2.15$, $p = 0.034$, [0.024, 0.587], when controlling for interest identities in arts, in sciences, and their interaction, $ts < 1$.

We also analyzed codings for quality of ideas, fluency, and elaboration, none of which were significant ($ts < 1$, $ps > 0.500$). These results may not be surprising considering our use of a temporary induction. In Study 2, where theories of interest were measured, participants had a history of applying their chronic implicit theory; therefore, those with a growth theory were more likely to have practiced integrative thinking in their daily lives, as demonstrated by their higher quality and more elaborative responses. In the current study, although those in the growth-theory condition were more likely to integrate the arts and sciences, the recency and temporary nature of the induction meant that

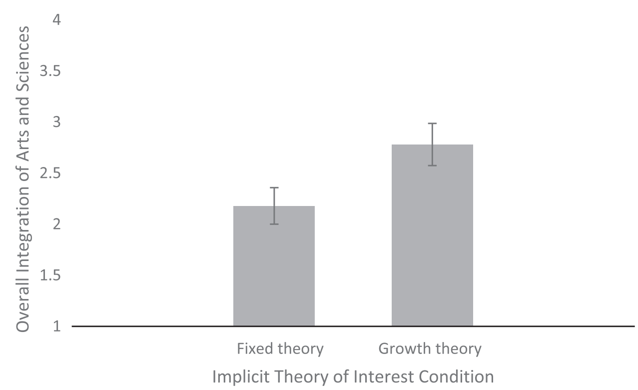

Fig. 4. *Mean degree to which participants' ideas for majors integrated the arts and sciences as judged by coders (Study 3). Note.* Results are presented for fixed-theory and growth-theory experimental conditions. The integration rating scale ranged from 1 to 7. Error bars represent standard errors.

participants would not have necessarily accrued the relevant experience and knowledge needed to develop higher quality or more elaborate responses.

5.3.3. *Word search task*

Preliminary analyses showed that participants found more arts-related words overall ($M = 3.80$, $SD = 1.57$) than sciences-related words ($M = 3.14$, $SD = 1.53$), $t(118) = 4.12$, $p < 0.001$, $d = 0.42$. Furthermore, although in the expected direction, participants were not more likely to find words that matched their interest identity as compared to mismatched it, $t(118) = 0.59$, $p = 0.554$, $d = 0.06$. Interestingly, however, those in the growth-theory condition ($M = 7.36$, $SD = 2.52$), as compared to the fixed-theory condition ($M = 6.42$, $SD = 2.55$), found more words overall, $t(117) = 2.03$, $p = 0.045$, $d = 0.37$, suggesting greater accessibility of words from both areas.

Critical to our hypothesis, and as predicted, those in the growth-theory condition found more words associated with the area mismatching their interest identity as compared to those in the fixed-theory condition, $b = 0.29$, $\beta = 0.19$, $t(117) = 2.11$, $p = 0.037$, [0.018, 0570] (see Fig. 5). The effect of theory-of-interest condition held, $b = 0.29$, $\beta = 0.19$, $t(114) = 2.21$, $p = 0.029$, [0.030, 0.559], when controlling for interest identities (z-scored) in arts, $t < 1$, and sciences, $b = 0.42$, $\beta = 0.27$, $t(114) = 1.62$, $p = 0.109$, [−0.094, 0.927], and their interaction, $t < 1$. By contrast, and as expected, theories of interest did not predict the number of words matching participants' interest identity, $b = 0.18$, $\beta = 0.11$, $t(117) = 1.20$, $p = 0.231$, [−0.117, 0.478]. Interestingly, because those in the growth-theory condition did not find fewer matching words—they found more words overall within the same limited time-frame—their increased attention to words outside of their interest identity did not come at the cost of attention to words that aligned with their interest identity.

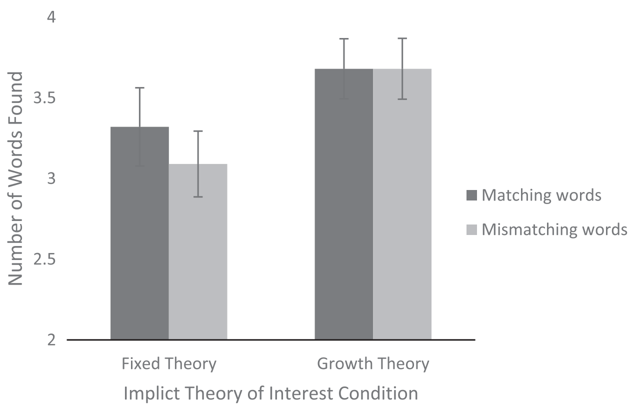

Fig. 5. *Mean number of words found in the word search task that matched and mismatched participants' interest identity (Study 3). Note.* Results are presented for fixed-theory and growth-theory experimental conditions. Error bars represent standard errors.

5.4. Discussion

Study 3 replicated and extended the central findings from Study 2 by demonstrating the causal role of theories of interest on integrative thinking. As compared to a fixed theory, a growth theory of interest caused participants to evince a stronger tendency to generate ideas that bridged their (arts or sciences) interest identity area with the one outside of it, and also facilitated attention to stimuli outside of their interest identity.

6. Study 4

The primary purpose of this study was to conceptually replicate and extend our findings from Studies 2 and 3—showing that a stronger growth theory of interest predicts a greater tendency to integrate an outside area with one's well-established interest area—in several key ways. First, we recruited a non-student sample in order to test the generalizability of the effect. Second, unlike the prior studies where participants' open-ended responses were coded, we analyzed participants' own ratings in an integration task. Doing so allowed us to test our hypothesis without having to interpret participants' responses. Third, we additionally controlled for participants' openness to experience (assessed as a personality trait) and their implicit theory of intelligence (beliefs about the malleability of intelligence). Although prior research has ruled out these two constructs as alternative explanations for why those with a stronger growth theory express more interest in areas outside their interest identity (O'Keefe, Dweck, & Walton, 2018a), we sought to test the role of theories of interest above and beyond these variables in the tendency to integrate the arts and sciences.

Finally, we examined one potential mechanism for why a stronger growth theory of interest predicts a tendency to bridge the arts and sciences: utility value of the outside area. Utility value refers to the perceived usefulness of something because it helps fulfill one's goal (e.g., Eccles, 2009). Because a growth theory of interest is associated with greater openness (O'Keefe, Dweck, & Walton, 2018a) and attention (Studies 2 and 3) to areas outside of one's well-established interests, people with this mindset may also come to see them as potentially more useful in general. In turn, this could explain why people with a growth theory are ultimately more likely to integrate the area with their well-established interest area. Therefore, we analyzed utility value of the outside area as the mediator between a stronger growth theory of interest and greater integration.

6.1. Method

6.1.1. Participants

To calculate our minimum required sample size, we used the effect size obtained in Study 2, in which theories of interest (which was also measured, not induced) predicted integration, $f^2 = 0.078$. With $1\text{-}\beta = 0.80$ and $\alpha = 0.05$, the minimum required sample size was 103. Given that we also sought to test a novel mediation hypothesis, we exceeded this amount. The study was conducted in the U.S. on Mechanical Turk where potential participants completed a brief prescreen to determine their eligibility. We sampled until 200 eligible participants were obtained, 185 of whom completed the study (84 female; $M_{age} = 36.42$, $SD_{age} = 10.81$). Participants were paid $1.50 USD for the brief online study.

6.1.2. Procedure

In the prescreen, we assessed interest identity, age, and student status. As in Studies 1–3, eligible participants were those who endorsed either an arts or sciences interest identity, not both or neither. Additionally, the prescreen excluded those who were currently a student and younger than 21 years old (as required by the authors' university IRB). Eligible participants immediately proceeded to the main study; the study was terminated for those not eligible.

In the main study, participants first completed the theories-of-interest scale and an assessment of openness to experience (used as a covariate), as well as several filler questions to further mask the purpose of the study. Then they completed two tasks for which they imagined they were a curator of a new arts or sciences museum. As in Study 1, they were assigned the type of museum (arts or sciences) that matched their interest identity. In the first task, assessing utility value, they rated the usefulness of eight common fields in the arts and sciences, equally represented, for creating new museum exhibits in general. In the second task, assessing integration, they reported how much they would draw from each of these fields to realize their vision for a particular exhibit. Finally, they completed the theory-of-intelligence scale (used as a covariate) and basic demographics. Unlike Studies 2 and 3, this study was not pre-registered.

6.2. Measures and materials

See Table 5 for descriptive statistics and correlations for all measures.

6.2.1. Interest identity

Interest identities were assessed and employed for recruitment similarly to Study 1, but with a key change to ensure comprehension. In Studies 1–3, our undergraduate participants commonly referred to themselves as an "Arts/Humanities person" or "Science/Technology person," and the academic fields encompassed by each category were well known at their university. Among the non-student sample obtained in the present study, we could not rely on that same understanding. Therefore, our items were more descriptive.

As the analogue of our arts item, participants read "For the statement below, 'AHLSS' refers to a general category that includes arts, humanities, languages, and social studies," and rated their level of agreement with "I am an AHLSS-oriented person." As the analogue to our sciences item, participants read "For the statement below, 'STEM' refers to a general category that includes science, technology, engineering, and math," and rated their level of agreement with "I am a STEM-oriented person." Two filler items were included to mask the purpose of the measures (these assessed the extent to which they saw themselves as a relationship-oriented and a sports-oriented person). Seventy-six participants had an AHLSS interest identity and 109 had a STEM interest identity. For continuity, we refer to these as arts and science interest identities, respectively.

Table 5
Descriptive statistics and correlation matrix (Study 4).

Variables	*M*	*SD*	95% CI LL	95% CI UL	1.	2.	3.	4.	5.	6.	7.	8.
1. Theory of interest	3.75	1.00	3.61	3.90	–							
2. Sciences interest identity	4.04	1.65	3.80	4.28	−0.09	–						
3. Arts interest identity	3.44	1.77	3.18	3.69	0.11	−0.89**	–					
4. Openness to experience	4.84	1.27	4.65	5.02	0.21**	−0.24**	0.33**	–				
5. Theory of intelligence	3.60	1.399	3.40	3.81	0.38**	−0.11	0.15*	0.38**	–			
6. Integration of mismatching area (%)	28.89	18.59	26.19	31.58	0.17*	0.07	−0.08	−0.04	−0.06	–		
7. Utility value of matching area	4.09	0.69	3.99	4.19	−0.07	0.07	-0.07	0.04	0.08	−0.37**	–	
8. Utility value of mismatching area	3.07	0.90	2.94	3.20	0.19**	0.17*	−0.18*	−0.04	−0.01	0.50**	0.05	–

Note. *M* = Mean. *SD* = Standard Deviation. CI = Confidence interval of the mean. LL = Lower level. UL = Upper level. $^*p < 0.05$, $^{**}p < 0.01$. Higher theory-of-interest scores indicate a stronger growth theory.

6.2.2. *Theories of interest*

Same as in Studies 1–3 (α = 0.80).

6.2.3. *Openness to experience*

Openness to experience was assessed using the Ten-Item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann Jr, 2003). Participants viewed 10 pairs of personality characteristics, with two items representing each Big Five personality dimension. They rated the extent to which they agreed or disagreed that the pair applied to them (1 = *disagree strongly*, 7 = *agree strongly*). The two items that assessed openness to experience were "I see myself as open to new experiences, complex" and "I see myself as conventional, uncreative" (reverse scored). The items correlated, $r(183) = 0.28$, $p < 0.001$, and a mean composite was calculated.

The TIPI was partially used to help mask the purpose of the study; however, openness to experience was intentionally assessed for use as a covariate, following past research (O'Keefe, Dweck, & Walton, 2018a). Greater openness to experience might predict why some people are more likely to integrate an area outside of their interest identity. Including this covariate allowed us to test the effects of theories of interest above and beyond this factor.

6.2.4. *Museum task and measures of utility value and integration*

This task was designed to assess the relation between theories of interest and (a) the utility value of fields from the outside area, and (b) the tendency to integrate outside fields with those from one's interest identity. Participants were assigned to the type of museum (i.e., arts or sciences) that aligned with their interest identity. To assess utility value, participants read:

> Imagine you are the curator of a brand new [*Arts* or *Sciences*] museum. The shape and direction that this museum takes is based entirely on your vision alone. Below is a list of common fields. In creating your museum exhibits, how useful (or not) would it be to draw from each of the following fields in creating your exhibits? There are no right or wrong answers.

Participants were presented with eight fields (Arts, Engineering, Humanities, Languages, Math, Science, Social Studies, and Technology) and rated their utility value for each on a 5-point scale (1 = *not at all useful*, 5 =*extremely useful*). As our mediator, we calculated the average utility value for the four mismatching fields.

To assess integration of the arts and sciences, participants read:

> Imagine you are the chief curator of an [*Arts* or *Sciences*] museum, and you want to design an exciting new exhibit. The shape and direction of this exhibit is entirely up to you. In thinking about your vision for this exhibit, you can draw, or not draw, from each of the fields below. There are no right or wrong answers. Assign a percentage to indicate how much of your exhibit would draw from each field. You may assign any percentage from 0% to 100% to each field, as long as the total across areas equals 100%.

Participants were presented with the same eight fields and assigned a percentage to each. As our outcome variable, we calculated the total percentage they drew from the four mismatching fields.

6.2.5. *Theories of intelligence*

To assess participants' theories of intelligence, we used a validated 4-item scale (Dweck, 1999): "You have a certain amount of intelligence, and you can't really do much to change it," "Your intelligence is something about you that you can't change very much," "To be honest, you can't really change how intelligent you are," and "You can learn new things, but you can't really change your basic intelligence." We reverse-scored the items and a mean composite was calculated. Higher scores reflect a stronger growth theory of intelligence (α = 0.95).

We assessed and employed this construct as a covariate in order to test whether theories of interest would uniquely predict perceived usefulness and integration of the mismatching area above and beyond theories of intelligence.

6.3. *Results*

We first present analyses for our two outcomes, and then a test of the mediation model.

6.3.1. *Integration of the outside area*

As predicted, a regression analysis showed that a stronger growth theory of interest predicted that people would draw from a greater percentage of the mismatching fields when creating new exhibits for their arts or sciences museum, $b = 3.20$, $\beta = 0.17$, $t(183) = 2.38$, $p = 0.018$, [0.547, 5.862].

Furthermore, the effect remained, $b = 4.35$, $\beta = 0.24$, $t(178) = 2.98$, $p = 0.003$, [1.470, 7.235], when controlling for interest identities in arts, $t < 1$, in sciences, $t < 1$, and their interaction, $t < 1$, as well as openness to experience, $t < 1$, and theories of intelligence, $b = -1.71$, $\beta = -0.13$, $t(178) = -1.55$, $p = 0.123$, [-3.898, 0.471]. (Because participants assigned a percentage from 0 to 100 to each of the eight fields, results for the percentage drawn from matching fields are redundant.)

6.3.2. *Utility value of fields from the outside area*

Next, we examined our hypothesized mechanism. As predicted, a regression analysis showed that a stronger growth theory predicted greater utility value for the fields outside of participants' interest identity, $b = 0.17$, $\beta = 0.19$, $t(183) = 2.67$, $p = 0.008$, [0.045, 0.302].

Furthermore, the effect remained, $b = 0.22$, $\beta = 0.24$, $t(178) = 3.19$, $p = 0.002$, [0.082, 0.350], when controlling for interest identities (*z*-scored) in arts, $t < 1$, sciences, $t < 1$, their interaction, $b = -0.30$, $\beta = -0.25$, $t(178) = -3.34$, $p = 0.001$, [−0.481, −0.124], openness to experience, $t < 1$, and theories of intelligence, $t < 1$.

Also as hypothesized, theories of interest did not predict utility value for the fields that matched their interest identity, $b = -0.05$, $\beta = -0.07$, $t(183) = -0.95$, $p = 0.344$, [-0.148, 0.052].

6.3.3. Mediating role of utility value in integrating the outside area

This analysis tested whether those with a stronger growth theory integrated more of the outside area because they viewed fields from that area as more useful. The analysis was implemented with the PROCESS macro for SPSS using 5,000 bias-corrected bootstrap samples (see Fig. 6). As reported above, a stronger growth theory predicted greater utility value, $p = 0.008$, which, in turn, predicted greater integration of the mismatching area, $b = 9.89$, $\beta = 0.48$, $t(182) = 7.32$, $p < 0.001$, [7.223, 12.551] (while controlling for theory of interest). The indirect effect was significant, [0.438, 3.138], while the direct effect was not, $b = 1.49$, $t(182) = 1.23$, $p = 0.220$, [−0.899, 3.876], suggesting full mediation. Results are nearly identical when all covariates are added to the model.

6.4. Discussion

Replicating our previous results, but with a different method, a stronger growth theory of interest predicted that people would draw more from fields outside of their interest identity, thereby integrating the arts and sciences more extensively. Furthermore, we found that this relation was mediated by participants' utility value for fields from the outside area. Thus, these results demonstrate that the greater integration predicted by a stronger growth theory reflected the utility value participants had for fields outside of their interest identity.

Moreover, by using a non-student sample, we found that our effects are not limited to undergraduates; they also apply after people leave school, many of whom join different organizations, workplaces, companies, and teams. Furthermore, and consistent with prior research (O'Keefe, Dweck, & Walton, 2018a), we found that participants' openness to experience and theory of intelligence did not alternatively explain our results.

7. General discussion

We began by asking, What mindset contributes to integrative thinking? One answer, our research shows, lies in people's implicit theories about the nature of interest. The present research builds on work showing that, as compared to a fixed theory of interest, a growth theory increases openness to new or different areas of interest (O'Keefe, Dweck, & Walton, 2018a). In doing so, we demonstrated that a growth theory increases attention to information from outside of people's well-established interest area, and increases the tendency to generate ideas that bridge people's well-established interest area with one outside of it. Moreover, we found that the utility value for the outside area helped explain why a growth theory predicted increased integration. Lastly, we found that a stronger growth theory predicted relatively higher quality integrative ideas overall. Taken together, these findings suggest that a growth theory of interest is a mindset that contributes to the kind of integrative, interdisciplinary thinking embraced by some of the world's most innovative people and organizations.

To demonstrate these effects, we investigated the role of implicit theories of interest in two broad academic areas—the arts and sciences; however, our findings are not theoretically limited to bridging only those areas. On one hand, this general categorization is common. Indeed, most universities implicitly endorse this division by creating separate schools, housed in separate buildings, for those who study one or the other. A growth theory, however, should enable people to think beyond conventional boundaries, whatever those may be, and to see connections among information, even within one of these two areas. For example, within the social sciences, economists have increasingly studied decision-making using perspectives and methodologies from psychological science, forging the field of behavioral economics. Connections can be forged across virtually any disciplines, and a growth theory may help facilitate that process.

The present research contributes new knowledge to the scientific literature on implicit theories—such as fixed and growth theories of intelligence (see Dweck, 1999; O'Keefe, 2013), of personality (Chiu, Hong, & Dweck, 1997), of relationships (Knee, Patrick, & Lonsbary, 2003), of willpower (Job, Dweck, & Walton, 2010), among others—further highlighting the important influence that implicit theories have on thought, motivation, and behavior. Yet theories about *interest* have unique implications and inspire novel hypotheses across a range of social behaviors. Perhaps most evidently, future research should further examine the role of theories of interest in innovation and creativity. For instance, much research has been devoted to identifying the core traits of highly creative people (e.g., see Feist, 1998, 2018; Gough, 1979; Martindale, 1999). Given that a growth theory promotes integrative thinking, as shown in the present research, does this mindset emerge as a core trait among highly creative individuals, or those who make innovative contributions to the arts, sciences, technology, business, and other fields? If so, can promoting a growth theory of interest help people to become more innovative in the long run?

The present studies also advance our scientific understanding of interest processes. In recent decades, research on interest has surged (see O'Keefe & Harackiewicz, 2017), yielding important insights into the different phases of interest, from curiosity (e.g., Kashdan, Rose, & Finchman, 2004; Silvia, 2017) to passion (see Vallerand, 2015), from situationally-triggered to well-developed individual interest (see Hidi & Renninger, 2006), and into the function of interest for learning and exploration, self-regulation, and motivation (see Fredrickson, 2001; Izard, 2013; O'Keefe & Harackiewicz, 2017; O'Keefe, Horberg, & Plante, 2017; Tomkins, 1962). Little work, however, has considered how *beliefs* about the nature of interest might shape how people think and behave. As research expands, we may find that theories of interest modulate what we currently consider to be relatively basic processes of interest. For example, how do implicit theories of interest affect the development of interest over time? If one believes that interests are fixed, would the development of new interests at times be thwarted before they can begin? Our research suggests that existing conceptions of interest development (e.g., Hidi & Renninger, 2006; Renninger & Hidi, 2015)

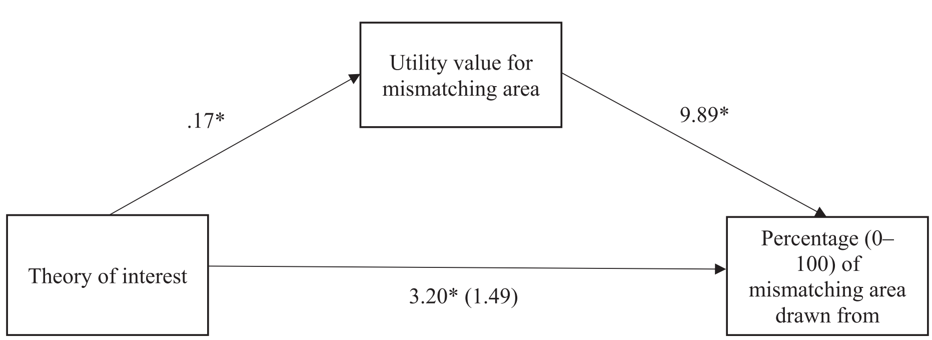

Fig. 6. Model testing the mediating role of utility value in the relation between theories of interest and the extent which participants drew from the mismatching fields to realize their vision for a new museum exhibit (Study 4). *Note.* Higher theory-of-interest scores indicate a stronger growth theory of interest. $^{*}p < 0.05$.

may benefit from incorporating people's beliefs about the nature of interest.

The present studies serve as the first step in understanding the link between theories of interest and integrative thinking, and the mechanisms that explain this process. Indeed, in Study 4, we demonstrated that one mechanism is the utility value for the outside area; however, others could be investigated. For example, a growth theory might also be associated with greater curiosity and motivation to learn about new topics. Given that interest can be sparked by a desire to fill gaps in one's knowledge (see O'Keefe & Harackiewicz, 2017), a growth theory may help initiate this process. In turn, that new knowledge may be integrated into one's pre-existing knowledge. Therefore, examining the mediating role of learning goals—achievement goals focused on learning and improvement (Dweck & Leggett, 1988)—may be well advised.

Notably, our research examined theories of interest in individuals who had a well-established interest in one area, but not the other (i.e., arts or sciences). How would fixed and growth theories relate to integrative thinking among people who have well-established interests in both areas? Because even those with a fixed theory would likely possess a depth of knowledge in both areas, we anticipate they would integrate equally as effectively. What about people who have not yet formed strong interests in particular areas, such as new MBA students being introduced to unfamiliar subjects like financial accounting, ethics, leadership, and optimization and simulation modeling? Those with a growth theory might still show a somewhat stronger inclination to bridge the areas than those with a fixed theory, but as novices, those connections may be shallow at first. Over time, however, their openness to new fields may cause those burgeoning interests to grow and deepen, increasing the likelihood of making substantive connections. Research will be needed to investigate these hypotheses.

Beyond basic scientific knowledge, a growth theory of interest has important applications for education and organizations (see O'Keefe et al., 2018b). With respect to higher education, a major goal of the liberal arts model is to broaden students' knowledge; to provide them with a solid foundation in a diversity of disciplines, rather than having them focus on only one or very few. A growth theory of interest complements this educational approach. Although schools and colleges offer many opportunities for learning different disciplines, as evidenced by a large diversity of academic programs, students holding a fixed theory may not pursue many of those opportunities. They tend to believe that their interests lie in limited areas, and are not as inclined to see how outside areas of knowledge can be connected and integrated with their existing interests. By contrast, those with a growth theory may be more likely to take advantage of learning across disciplines, perhaps, for example, even completing minors in areas outside of their pre-existing interests or designing their own interdisciplinary majors. By extension, a growth theory may help students prepare for a job market that is increasingly more interdisciplinary.

With regard to organizations, companies might stand to gain from hiring people with a growth theory of interest, and promoting a growth theory among their members. Companies searching for innovative solutions to contemporary problems might find more insightful solutions by drawing from multiple areas. Fitbit, for example, develops and manufactures technologies to promote healthy living. In doing so, its employees draw from computer science, engineering, the social sciences, and industrial design, among other fields, to create products that resonate with people and motivate them to lead healthier lives. Moreover, innovative companies might benefit from teams composed of people with a growth theory (O'Keefe, Dweck, & Walton, 2018b). Working in disciplinarily diverse teams, these people may be more likely to contribute their deep knowledge in some areas, and to collaborate with others from different backgrounds. They may also be more receptive to what they can learn from other team members. A team composed of employees holding a fixed theory, by contrast, may be less likely to make contributions across disciplines and to appreciate the value of contributions from other areas.

Our work also has implications for people seeking employment. This matter is particularly critical given that many jobs are becoming automated or replaced with artificial intelligence, meaning that more common occupations are increasingly becoming obsolete, leaving more and more people unemployed (Manyika, et al., 2017). Such people may need to seek occupational retraining. A growth theory may open them to considering jobs and careers outside of their current vocational interests, which may require new skill sets. People with a growth theory of interest may be more likely to seek such retraining and be more successful at making the transition than those with a fixed theory.

A growth theory may also be important for forging connections across one's work tasks. While a growth theory might not make highly-disliked work tasks interesting to employees (e.g., collating and stapling), it could make some mundane activities more engaging. This may be particularly true if a growth theory helps employees draw connections between those mundane activities and the work they care about most. For example, by connecting those activities to their core vocational interests, a growth theory might help make mandatory training, certification procedures, or skills development workshops more meaningful and engaging, rather than something to merely endure.

Beyond business and organizations, solutions to major, global problems may be better addressed by people who bridge disciplines. Climate change, for example, will not likely be solved by new engineering technologies alone. Solutions will also need to address social factors, such as changing consumer norms and voting behaviors, among others. Those with a growth theory may help lead the way in solving such critical problems.

8. Conclusion

In a world that is more interconnected than ever, many of our complex problems will be solved by integrating knowledge from diverse fields. It is therefore vital to promote mindsets for thinking beyond traditional boundaries among students, employees, organizations, and businesses. To that end, being open to new fields and their potential value for problem-solving will be critical moving forward. A growth theory of interest may play a pivotal role in our tendency to do so.

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Paul A. O'Keefe: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing, Supervision, Project administration, Funding acquisition. **E.J. Horberg:** Conceptualization, Methodology, Writing - review & editing. **Anandita Sabherwal:** Investigation, Writing - review & editing. **Gabrielle C. Ibasco:** Investigation, Writing - review & editing. **Adlin Binti Zainal:** Investigation, Writing - review & editing.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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