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Evolution hesitancy: challenges and a way forward for teachers and teacher educators

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Abstract

Background It has long been acknowledged that evolution is a difficult topic for many students, partly because of the conceptual demands it makes, and partly because for some students an acceptance of evolution conflicts with their religious beliefs. The study we report on here was designed to see if there were additional reasons why evolution might be a difficult topic for certain students.

Results Using in-depth, semi-structured interviews with seventeen adults studying for education qualifications, we show that evolution is a difficult topic for certain people because it can give rise to existential concerns. Thematic content analysis of interview transcripts revealed six themes associated with existential concerns: time, identity, death, responsibility/freedom, meaninglessness, and isolation. Analysis revealed that the topic of evolution frequently gave rise to feelings of disquiet.

Conclusions Because it concerns issues to do with death, extinction and change, evolution can be deeply unsettling for many people, even if they may have difficulty articulating why this is so. Teachers when they teach evolution therefore need to consider at least three overlapping constituencies who may find evolution difficult: those for whom it is cognitively challenging; those who reject aspects of evolution on religious grounds; and those who are uncomfortable with evolution for existential reasons. Teacher educators need to decide how best to prepare new teachers for these challenges. We argue that a pedagogy based on two approaches—treating evolution as a conceptually demanding topic and treating it as a sensitive issue—may provide a way forward.

Keywords Evolution hesitancy, Existentialism, Evolution pedagogy, Sensitive issues

Background and literature

For the vast majority of biologists and biology educators the theory of evolution helps make sense of all of biology. Yet, as is well known, there are many who reject the mainstream scientific account of evolution. Indeed, so important is evolution in affecting how one understands the diversity of life, including its origins and history, that Charles Darwin famously described his emerging thinking on transmutations to his botanist friend Joseph

Hooker as “like confessing a murder” (Desmond and Moore 2009, p.314). To this day, there are many parts of the world where the theory of evolution remains deeply contentious. The idea that life on Earth has evolved over millennia from a universal ancestor remains to this day an unacceptable idea for many people, despite the fact that evolution is considered by contemporary biologists as the central unifying theory of their science (Sager 2008). Surveys regularly show that acceptance of the theory of evolution varies greatly between and within countries (Miller et al. 2006; Kuschmierz et al. 2020).

This article reports on an exploratory study and draws on a theoretical and literature base that is not often applied to studies of science education. The theoretical framework adopted is psychosocial, drawn from

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psychoanalytical theory and existential philosophy (Yalom 1980). The main assumption of this framework is the existence of the human unconscious. Our hypothesis is that some resistance to evolution may result from unconscious, existential associations with some of the concepts that can be associated with evolution in people's minds, the principal ones being change, extinction, the vastness of geological time and human identity as animals.

Famine and death

This research began with a kernel of an idea, namely that evolution could perhaps bring to mind disturbing notions, and an associated question: can all resistance to the theory of evolution be explained by people's religious beliefs? The idea originated from Darwin's own words in *The Origin of Species* (1859). The end of the book contains what has come to be known as the Tangled Bank quotation, which concludes: "Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving, namely, the production of the higher animals, directly follows" (Darwin 1859, p.490).

This quotation hints at the difficulty raised by the idea of natural selection beyond problems of conceptual understanding. It lays bare the idea of the struggle for existence, something potentially disquieting. Change also is understood to be something people often resist. In fact, a whole industry of change management has arisen to help large organizations in the private and public sectors to manage changes such as mergers and restructurings (Tsoukas and Chia 2002). Evolution is underpinned by the concept of change; arguably, we are currently in an era of accelerating change and instability. In biology, where evolution emphasizes the instability that is all around us, are we currently missing something in our examination of barriers to evolution acceptance and/or understanding?

Acceptance and understanding

As is well known, religiosity is a significant contributing factor to the non-acceptance of evolution by certain individuals (Scott 2004; Long 2011). Evolution is also a conceptually difficult topic in biology. Much of the academic research has examined cognitive barriers and the conceptual difficulties that evolution presents (Sinatra et al. 2008; Gregory 2009; Shtulman 2011). For instance, Bardarpurkar (2008) captures a fundamental misconception held by many children which is perceiving evolution as "individual transformation" (Bardarpurkar 2008, p.304), born of necessity—a process of personal adaptation driven toward a particular end. The reality is that evolution is concerned with far more unpredictable

events, often acting over long time periods and on assemblages of individuals.

Misconceptions are not just demonstrated by children; examinations of adults' understandings of evolution have indicated that the same misconceptions seen in children's explanations are frequently exhibited by adults, even by some of those teaching biology (Brumby 1984; Nehm and Schonfeld 2008; Smith 2010; Rosengren et al. 2012; Friedrichsen et al. 2016).

Intuitive biological thought: folk biology, teleology and essentialism

There is a body of research that suggests that people intuitively think about biological entities in a way that is fundamentally different from how they think about non-living things such as rocks and stars (Atran 1998). Among these intuitive conceptions is the idea of essentialism: the belief that living things have eternal, immutable identities or essences. People with essentialist notions see organisms as having an underlying, unseen nature that gives them their distinctive characteristics (Samarapungavan and Wiers 1997; Rudolph and Stewart 1998; Sinatra et al. 2008; Blancke et al. 2011). This type of thinking is most common in young children but can persist into adulthood. There is evidence that our thinking tends to lapse into essentialist positions under pressure, when we encounter something unfamiliar (Sinatra et al. 2008).

Another form of intuitive biological reasoning is teleological (goal-directed) thinking. Such reasoning sees the adaptations of organisms as existing to fulfil specific pre-existing needs, such as (for a plant) to grow taller or for animals to become more intelligent. This allows for variation within a species and subsequent selection, but the selection is purposeful and towards a particular end (Rudolph and Stewart 1998; Sinatra et al. 2008; Kampourakis et al. 2012). In addition, teleology can be associated with ideas of intentionality and agency that may underpin creationist beliefs (Sinatra et al. 2008; Blancke et al. 2011). Such intuitive ideas are resistant to change and present a significant issue for educators. Effective learning may require a radical change in how a person understands the world. In combination, these ideas "encourage us to see our world as unchanging, orderly and commonsensical" (Sinatra et al. 2008, p.191). They allow us to perceive purpose and meaning where there may be none, giving the impression of a predictable and coherent world. The reality of evolution is more likely to be associated with descriptions such as 'unstable' and 'change', which are highly value-laden. Perhaps conceiving of nature as stable, predictable and enduring is our preferred view of nature? Evolution may present a challenge to our perception of the world as stable and imbued with purpose, exposing existential questions.

Evolution and affect

Although work on the importance of the affective domain for difficulties in understanding and accepting the theory of evolution is not as advanced as our understanding of cognitive and religious barriers, some themes are emerging in studies of evolution education that enable us to begin to look at how affective barriers may work. In particular, some research indicates that evolution provokes negative reactions not directly associated with religious belief. For instance, a study by Brem et al. (2003), examining the perception of evolution among a diverse group of US college undergraduates, found that despite controlling for religious belief, a *greater* exposure to information about evolution appeared to be correlated with a more *negative* attitude to accepting evolutionary theory. The negative consequences of acceptance perceived were related to greater selfishness and racism, coupled with a lack of purpose to life and diminished spirituality. Blancke et al. (2011) also cite people's negative perceptions of the perceived randomness and lack of direction associated with evolution, as well as the consequences of human and animal suffering. Bizzo (1994) interviewed a group of high school students in Brazil, including those of no stated faith, and found that many students tended to perceive biological conceptions of competition as acts of violence.

An unusual perspective on affect and evolution comes from the literature not on education but from examining the beliefs and attitudes of social scientists. De Baca and Jordan (2012) discussed resistance by social science researchers to employing evolutionary explanations to understand human behavior. They acknowledged the justified concerns of social science researchers that evolutionary explanations risk ignoring important social and cultural factors and can justify inequality and promote discriminatory political agendas. However, De Baca and Jordan also evidenced the role of meliorism, an emotionally-based personality trait which is "the concept that human beings are inherently good and possess the agency to rid the world of injustice" (2012, p.683). Meliorism, De Baca and Jordan argue, was a common affective barrier for acceptance of evolutionary explanations which may point to a form of denial and splitting off of knowledge.

One further study also pointed to the possibility of deeper and more opaque feelings about evolution. Tracy et al. (2011), looking specifically at people's feelings towards Intelligent Design and evolution, found that exposure to prompts reminding participants of their own mortality was associated with increases in acceptance of Intelligent Design and rejection of evolution. This finding was irrespective of participants' faith. Four studies were conducted: two involved undergraduate psychology majors from predominantly liberal North American

universities, a third study recruited a more diverse range of North American undergraduates, and in the final study the participants were North American adults of diverse socioeconomic and educational backgrounds.

The researchers found that death reminders increased acceptance of Intelligent Design and/or rejection of evolution, regardless of religion, degree of religiosity, educational background, or the participants' prior attitude toward evolution. They suggested that "attitudes toward scientific (or seemingly scientific) views and ideologies can be partly shaped by unconscious psychological motives to maintain security and ward off existential angst through the cultivation of meaning and purpose" (Tracy et al. 2011 p.12).

Teleology and affect

Research suggests that human beings possess a bias toward perceiving purpose and intention in the natural world (Kelemen 1999). Studies of children's reasoning indicate that young children demonstrate a generally intuitive understanding of nature as purpose-based (Kelemen 2004), and are often inclined to perceive natural phenomena as intentionally created, which is not fully explained by the religiosity of their home background (Evans 2000).

Teleological reasoning is less apparent in older children and adults but in some contexts remains a significant feature of people's explanations. Faith-based explanations may be responsible for much of people's belief in supernatural agentive creation but it appears that the perception of agency in nature is not always a result of religion. There is evidence that adults who fully accept scientific explanations have a tendency to see agency in natural processes such as evolution, seeing natural selection as a purposeful response to an organism's needs (Kelemen 2012; Jarnefelt et al. 2015).

Although disagreements exist regarding the mechanism behind needs-based reasoning, there is evidence to suggest that it may be the product of automatic, intuitive cognitive processing established early in development (Evans 2001; Kelemen 2004). This conclusion is supported by the work of Jarnefelt et al. (2015) who used time-constrained and non-time-constrained tasks to investigate religious, non-religious, and specifically atheist US and Finnish adults. They found that the non-religious and specifically atheist adults in both Finland and the USA demonstrated a tacit tendency to view nature as purposefully created. A notable observation was that within the non-religious groups what the authors term 'Gaia beliefs', a belief in Nature/the Earth's intrinsic agency, predicted a greater tendency to see natural phenomena as purposefully created. This result was found in conditions when the participants were put under time

pressure to respond. This is explained by the theory that this automatic or intuitive type of reasoning is more accessible to people under such conditions; however, other studies have found similar evidence of perceived design in nature in non-religious adults under conditions without such restraints (Preston and Shin 2021).

The dual process model argues for a significant role of innate cognitive tendencies in humans that persist throughout life at an intuitive and automatic level of processing. Kahneman (2003) famously described two styles of processing: ‘intuition’ (or system 1), which is fast and automatic, usually with strong emotional associations and is enduring; and ‘reasoning’ (or system 2), which is a slower, more stable and conscious. Jarnefelt et al. (2015) found evidence that this intuitive type of processing is a greater determinant of people’s needs-based reasoning than cultural exposure. This may help explain the difficulty children and adults have in understanding fundamental scientific ideas which conflict with their intuitive ones, and highlights the difficulty of the task for educators (Kelemen 2004); learning about evolution is not necessarily “an unproblematic conceptual bridge in a process of theory revision from an intuitive creation-based theory of natural origins to one based on nonintentional evolutionary processes” (Jarnefelt et al. 2015, p.84).

Preston and Shin (2021) found that intuitive teleological thinking that finds design in nature is more strongly elicited when the natural phenomenon in question is perceived as supporting human life. Evolution is discussed as case in point, as lay persons’ perceptions are often of a directed process that typically supports animal survival (Shtulman 2006). Preston and Shin suggest that this may be due to an innate tendency to view humans as special, inflating the significance of human life in relation to that of other species. Anthropocentric thinking significantly influences how we see other animals (Berger 2009; Carey 1985). Presumptions of our superiority are widespread in Western culture and this mindset is apparent in a number of common misunderstandings of evolution (Shtulman 2006; Evans and Lane 2011). An implication of Darwinian evolution, that we are not the pinnacle of the tree of life but just another branch, is therefore potentially disturbing to many (Preston and Shin 2021).

Terror management theory and the dual process model

So, research indicates that a preference for teleological beliefs may be the result of a number of cognitive factors including dual processing. However, Davis et al. (2011) go further and suggest that motivational forces may also be at the heart of people’s seeming preference for goal- or needs-based reasoning about nature. Specifically, they propose that teleological beliefs stem from, in part at least, humans’ consciousness of their mortality,

as teleological beliefs may mitigate death anxiety in the face of this awareness. According to terror management theory (TMT), death awareness leads people to develop an anthropocentric worldview, human specialness as a means of protection against corporeal vulnerability (Solomon et al. 1991).

Psychologists Pyszczynski et al. (1999) implicate the dual process model in TMT, as it identifies two systems by which the brain may manage death anxiety: namely system 1 (unconscious) and system 2 (conscious). TMT is rooted in the work of Ernest Becker (2007). Becker asserted that “all culture, all man’s creative life-ways are in some basic part of them a fabricated protest against natural reality, a denial of the truth of the human condition and an attempt to forget the pathetic creature that man is” (Becker 2007, pp. 32–33).

Davis et al. (2011) apply TMT theory to the origins of teleological explanations of natural phenomena: “Teleological beliefs are believed to be existentially soothing because they suggest that the world is not just a mass of inanimate, passive objects, but is a place where things happen for a reason, and by extension humans happen for a reason, and thus have significance beyond their physical and mortal existence” (p.99). Teleological explanations may therefore be an integral aspect of people’s need to cope with the conscious knowledge of their own mortality. In support of this, the literature indicates that reminders of our own mortality may generate a powerful psychological need to distance ourselves from other creatures and declare “I am not an animal” (Marino and Mountain 2015, p.7).

In summary, teleological, needs-based reasoning and anthropocentric beliefs may perform a protective function against existential concerns. The extensive literature on misconceptions in scientific understanding has examined the cognitive processes behind intuitive ideas but has not considered in depth the possible defensive function of teleological misconceptions and possibly other types of misconception such as essentialist beliefs. It is possible to argue that the kind of unconscious responses elicited by free association (as we describe in our methods below) could help tap into the system of one type of processing, namely, the innate, emotionally bound and automatic one.

Misconceptions and affect

Extinction

Extinction is a fundamental concept in evolutionary biology, but also a potentially disturbing one. A lack of understanding of this key idea and its relevance to humanity has been posited as one reason behind some individuals’ concern regarding anthropogenic environmental destruction (Leakey and Lewin 1995). A study

by Poling and Evans (2004) examined a group of 68 US preschoolers' and their parents' understanding of the concept of death, and their ability to explain death and extinction. The children and adults alike were resistant to the potentially inevitability of extinction for all species, but were particularly resistant to the possibility of human extinction. A comparative study was also carried out with medical students, eliciting similar responses. The authors suggested that the concept of extinction may provoke existential concerns (Poling and Evans 2004).

Evolution as progress

Research clearly indicates that the public, including undergraduate biology students, frequently incorrectly understands evolution as progressive, with humans being the pinnacle of evolution and its ultimate goal (Lord and Marino 1993; Alters and Nelson 2002). This is deterministic thinking with an anthropocentric twist. The literature cites possible cognitive reasons for this and also acknowledges the role of religious belief (Alters and Nelson 2002), but what remains largely unacknowledged in science education are the origins of anthropocentric thinking. Henry Gee describes this misconception as “aspirational thinking” (Gee 2002, p.611). Do we need to bolster our importance to seem less vulnerable to the vagaries of nature?

It is helpful in thinking through an unfamiliar lens, in this case existential concern, to draw on alternative literature to that of the traditional science education literature. For instance, in anthropology, Crist and Kopnina (2014) suggest it is imperative to question our often anthropocentric beliefs, values, and attitudes that guide our actions as they may represent a significant contribution to contemporary problems such as our current ecological crises. As they put it, the Western world at least “has regularly inquired into ‘the nature of the human’ through posing the question: How are humans different from all other life forms?” (Crist and Kopnina 2014, p.388).

Time

An understanding of large geological timescales, such as those required for evolution, is rare among the general public. Studies of school and university students in the UK and the USA indicate that many do not have an accurate conception of the age of the Earth, often hugely underestimating it (Oversby 1996; Libarkin et al. 2005). However, in addition to the sizeable cognitive barriers to understanding immense periods of time, there is an argument for acknowledging the possible significance of affect, specifically anxiety. As Stephen J. Gould (1987) put it, the discovery of deep time imposes an existential challenge: “What could be more comforting, what more convenient for human domination, than the traditional

concept of a young earth, ruled by human will within days of its origin. How threatening, by contrast, the notion of an almost incomprehensible immensity, with human habitation restricted to a millimicrosecond at the very end!” (Gould 1987, p.2).

A new direction?

So, from the conventional literature on understanding and acceptance of evolution a new perspective tentatively begins to emerge, one that possibly points to something fundamentally unsettling about evolution as an idea, but how can this be characterized? Many of the ideas that may provoke anxiety could be considered as those engendering an existential threat. The evolution of humans is also differentially rejected compared to other organisms. It is well documented that most of the resistance to Darwin's ideas occurs when they are applied to humans (Miller et al. 2006; Glaze 2018). Do Darwinian concepts imply something we would rather not acknowledge, such as our relationship to other animals, including apes, and so highlight something we have in common, the brevity and vulnerability of our existence?

It seems possible, therefore, that some of the key notions of evolution—that the universe may not have a pre-determined aim, that chance has played a major role in our being here, that we share a common ancestry with other species, and so on—can cause existential anxieties. Faced with these anxieties, a learner may feel safer consciously or unconsciously pushing evolutionary ideas to the back of their mind. However, it remains the case that the literature on this reason for avoiding evolutionary ideas is thin. This study was therefore undertaken to address the research question ‘Do certain concepts implicit in the theory of evolution, such as change, extinction, the vastness of geological time, and humans as animals, provoke affective existential responses in some people?’

Methods

In attempting to examine affective responses to evolution, the predominant methodological approach used was psychosocial. Previous studies investigating responses to evolution have used a range of methods from attitudinal surveys to in-depth interviews and observations. This study aimed to look at the issue in a somewhat different way. We are interested in the possible importance of unconscious as well as conscious responses to evolution. We therefore drew on the thinking behind narrative interviewing with a degree of free association (Hollway and Jefferson 2012), as a means of exploring conscious and unconscious affective responses.

The interview process: design and delivery considerations

The interview approach used was semi-structured (see Additional file 1: Appendix 1 for the interview schedule). However, the questions asked of all interviewees were very much starting points for questions which emerged as the interview progressed. This is interview as dialogue or conversation, encouraging free association of ideas (Lertzman 2019).

Hollway and Jefferson (2012) argue that language and therefore people's storied accounts are full of a "range of unexamined meanings"; we don't always "tell it like it is" (2012, p.2); rather, we are defended subjects. Accepting this is central to understanding the approach taken in this study that aims to examine both conscious and unconscious responses, those possibly unexamined meanings. Free association is a tool of psychoanalysis which can be used in interview design and interpretation. Through free association, certain words, phrases, or expressions may be suggestive. Such a method of interviewing relies on open-ended questioning, encouraging an attitude of reflection, even reverie, of unguardedness (Lertzman 2019).

The principle of free association was therefore used in the approach taken to the interview questioning and draws on Hollway and Jefferson's (1997) approach of Free Association Narrative Interviewing (FANI). The aim was to elicit responses, accounts and feelings from the interview participants through unstructured questions, asking them to let the interviewer know whatever came into their mind. The rationale for this is to elicit a narrative that is at least partly guided by unconscious thoughts and feelings, which may not be accessible by more traditional interviewing methods (Hollway and Jefferson 2012). For a full account of the procedure see Newall (2021).

The first part of the interview asked for information on the interviewee's school experience generally and then became increasingly specific, probing how they felt about school science and any recollection of learning about evolution or Darwin. This set the scene for the main part of the interview which concerned discussion of the visual prompts, details of which are given below. In this part free association questioning was used. Finally, the interview drew to an end by asking if the participant had a faith and, if so, what it was.

Visual representations and meaning

In devising the interview schedule, the aim was to provide a very loose structure around which could be explored the participants' thoughts and feelings towards evolution generally and, more specifically, responses to a number of visual artefacts that in some way represented

potentially existential aspects of evolution. These visual artefacts or prompts were:

1. A textbook illustration depicting an evolution *timeline* (available at <https://www.teacherspayteachers.com/Product/Timeline-of-Life-Research-Project-3040154>);
2. A 30-s *video* art work (*Origin* by Daniel Lee) that shows a fish transforming via intermediate stages into a man (available at <https://www.youtube.com/watch?v=WX87TkLTYN0>);
3. A set of photographic *portraits* (taken by James Mollison) of great apes (available at <https://www.jamesmollison.com/james-other-apes>).

These research probes were chosen as they represented key evolutionary ideas including change, extinction, the struggle for existence, the vastness of geological time, and humans as animals. Visual prompts in interviews are sometimes used for research into sensitive or potentially controversial topics and can assist in examining people's attitudes, beliefs and perceptions (Robson 2011). This study was attempting to probe potentially hidden or difficult thoughts and feelings, and those of a nature potentially hard to describe; visual depictions of the concepts may prompt a richer set of responses from participants than verbal questioning alone. The stimuli were chosen because they each could represent one or more of the existential ideas that evolution may signify to some people, these being change and instability, insignificance, struggle, vulnerability, and death. They were not chosen for their biological accuracy or usefulness in education, and it was expected that they might elicit misconceptions. It was purely the affective response that was being examined.

The first stimulus, the timeline, looked like an image they may have seen before in school textbooks. The second was a video artwork displaying an artist's interpretation of evolution through a shapeshifting creature. The third, the photographs, were passport photograph style full facial shots of great apes by photographer James Mollison.

The participants

A pilot interview was carried out with a volunteer. The sample size and available population meant that it was not possible to provide a representative sample of a population. The sampling employed was largely purposive, and interviewees were all pre-service educators at two London universities at various stages of their courses; the majority of them will not have been taught evolution on their current courses. Eighteen research participants were recruited; seventeen interviews were fully analyzed

(one interviewee was not a student and therefore did not comply with the sample criteria and his interview was not analyzed, nor was that of the pilot interviewee). All those who featured in the analysis were undergraduate or postgraduate students. The rationale for recruiting students of education was that as adults their ideas and perceptions are likely to be more fully developed than school students, but as a significant number of them are young adults they may retain a recent memory of school biology. They also have a particular interest in education.

Additional file 2: Appendix 2 gives details of interviewee characteristics and their pseudonyms. Demographic data was not formally collected with the exception of religious faith. Nevertheless, personal information, such as ethnicity, was volunteered by some participants during the interview and they were a highly diverse group of adults in terms of gender, ethnicity, age, and specialism, as well as faith. Each interview lasted about one hour, was audio-taped and transcribed; interviewees were given a £25 gift voucher as a ‘thank you’ for their time and involvement. Approval for the research was granted by the Research Ethics Committee of our university.

The theoretical framework: psychoanalysis and existentialism

The methodology for the qualitative analysis was drawn from existentialist psychoanalytical theory. Existential psychoanalysis is a branch of psychoanalysis; as its name suggests, it combines existentialist philosophy, principally that of Martin Heidegger, with psychoanalysis (Thompson 1998).

The term ‘existential’ is difficult to define; in the realm of existential psychotherapy, Irvin Yalom describes the existential orientation as a focus on concerns “that are rooted in the individual existence” (Yalom 1980, p.5). Existence encompasses the past, present, and future; it refers to our origins, our identity, meaning and purpose, and our potential fate. So, by its very nature, evolution is associated with the existential. Yalom described the existential approach as “deeply intuitive” (Yalom 1980, p.5) and the existential position as “a conflict that flows from the individual’s confrontation with the givens of existence” (Yalom 1980, p.8), an inevitable part of being human. This also means it is appropriate for an examination of normal responses to existence. Existential psychoanalytical theory could serve as another way of examining and understanding people’s emotional responses to evolution and possibly as a result provide a framework for understanding the non-acceptance of evolution beyond the role of religious faith.

Irvin Yalom’s writing provides four categories of existential concern that confront us; these “ultimate

concerns” (Yalom 1980, p.8) are death, responsibility/freedom, isolation, and meaninglessness, and they may stimulate conscious or unconscious anxiety. Although, as in Freudian psychoanalysis, anxiety provokes defense, that anxiety is not understood in existential psychoanalytic theory as being in response to drives, but in response to an “awareness of ultimate concern” (Yalom 1980, p.10). The four categories of concern in relation to evolution, based on Yalom’s definitions, are as follows:

Death

We know death is a reality, but we can choose to overlook life’s fragility. In relation to nature, we may choose to see the beauty in seasonal change, rather than the decay and death winter may bring. On a more personal level, thoughts that linger on death in nature may serve as a reminder of our own mortality, so we may avoid such associations. In an attempt to avoid the thoughts associated with death we may rely on fantasies of specialness or invulnerability. Yalom suggests that “Our belief in exemption from natural law underlies many aspects of our behaviour” (Yalom 1980, p.121). Heidegger (1927/2010) described this as a state of forgetfulness of being. However, certain ideas or situations may act to remind us and provoke anxiety. Evolution, as an idea associated with the struggle for existence, competition, death, and the possibility of extinction, could provoke defenses as an attempt to deny death.

Responsibility and freedom

Freedom in the existentialist sense is freedom to create our own meaning, to make choices and take actions. The implication of this is that any apparent structure or coherence in the world is the product of human thought or action; it is ours to own, and we are free to superimpose what we wish on reality; we create our own reality. However, in consequence the implication is that we are not revealing a pre-existing reality that we can observe; rather, each individual is responsible for creating their own life’s structure and meaning.

Responsibility, in the sense that true meaning only exists as created by an individual, is inextricably aligned with freedom, as freedom is necessary for an individual to constitute their own world (Yalom 1980). This responsibility is profound, and Yalom suggests not something we are aware of as we go about our daily lives. When it comes into self-awareness, it can cause us to question everything we see described as a state of groundlessness.

Isolation

Intimately linked with this freedom is the understanding that we are inevitably alone. This does not refer to interpersonal isolation, although it is related to it, but

isolation in its absolute sense. We enter and leave existence on our own, and it is our confrontation of this that prompts concern. This idea can be very much in conflict with our need to feel “part of a larger whole” (Yalom 1980, p.9). Such isolation is not grasped by us most of the time; we live in a state of everydayness, surrounding ourselves with things to which we attach significance. However certain circumstances, such as a confrontation with our own mortality, may reveal this isolation, the “unbridgeable gulf between oneself and another human being” (Yalom 1980, p.355).

Meaninglessness

“If we must die, if we constitute our own world, if each is ultimately alone” (Yalom 1980, p.9), what meaning does life have? This is to become aware that any supraordinate structure or coherent meaning is of our own making. There is no plan, we are not actors on a stage with a role supplied for us. If we accept this, then we must also accept that the world is unconcerned with us; it is indifferent. To conclude that the world continues only by natural forces, that our life has no ultimate purpose, is profound indeed.

Analysis

The data were analyzed cyclically, applying three levels of analysis (for a full account see Newall 2021). Analysis was undertaken primarily by EN with both the overall approach and specific details discussed extensively with MJR, especially when decisions had to be made or when the identification of themes, or allocation to codes or themes proved problematic.

First and second levels of analysis: psychoanalytical theoretical framework

All seventeen interviews were initially analyzed deductively using three themes identified from the literature as described in the literature review: ‘human significance’, ‘change as something to fear’, and ‘our identity as animal’ (Samarapungavan and Wiers 1997; Solomon 1991; Sinatra et al. 2008). As part of the first two levels of analysis, the interviews were also examined for evidence of psychic defense or unconscious dynamics. This was necessary as an assumption of the theoretical framework was that some responses may be unconscious and therefore revealed through psychic defenses against anxiety (Hollway and Jefferson 2012). Anxiety in this case is likely to be disproportionate to any perceived threat; Klein (1998) termed this ‘depressive anxiety’. This presumption in turn requires a particular approach to analysis as Hollway and Jefferson describe: “The idea that anxiety leads to distortions and displacements demands a methodological strategy designed both to recognize and decode

anxiety’s many guises” (Hollway and Jefferson 1997, p.55). In the first level of analysis of the interview transcripts, the notions of psychic defenses, transference, and other unconscious dynamics were applied to the data, looking for contradictions, indicative words, or phrase choice, but also more direct or obvious evidence of anxiety, ambivalence, and attempts at meaning making in the participants’ responses. Evidence of psychic defense was analyzed using a psychoanalytical framework drawn from the work of Sigmund Freud (1915), Anna Freud (2015), and Melanie Klein (1998).

The first level of analysis involved multiple readings of the data, highlighting key words, phrases, and sections, and labelling these with notes on defenses identified, allowing initial codes to be drawn up.

Eight ‘core’ interviews were then chosen from the original seventeen using two criteria: interviewees who did not seem to have been influenced by religious beliefs; interviewees who revealed the most indication of existential concern. The exception to the first criterion was Zara. Zara was a practicing Christian; as such, her responses were clearly informed by her faith. However, she also exemplified some of the most evident existential concerns and also had experience of knowledge as trauma which is significant for our interpretation.

Analysis of the eight interviews was undertaken, first using the approach of narrativization to produce narrative pen portraits of the eight core interviews, then an approach that created pathways of association. These methods were drawn from the research of Hollway and Jefferson (2012). An example of each approach for one of the interviews is given in Additional file 3: Appendix 3. The intention was, after fragmenting the data at the first level, to treat the interview holistically at the second level, to produce an analysis that also considered evidence of psychic defense.

This process ensured that the data were analyzed holistically and hermeneutically, as in hermeneutics parts of the text are examined to make meaning of the whole and the whole in turn examined to understand the parts, in a cyclical fashion (Alvesson and Skoldberg 2000). In analyzing the interviews using psychoanalytical theory it was important to examine them holistically. The reason for this was the concern that otherwise it might not be possible to capture the emergent thoughts and feelings prompted via free association through the normal process of conventional thematic analysis alone.

Third level of analysis: existential theoretical framework

The interviews were then analyzed thematically using the themes that emerged collectively at the first and second levels of analysis and derived from existential psychoanalytical theory (Yalom 1980). These six themes were time,

identity, death, responsibility/freedom, meaninglessness and isolation. These themes demonstrated what Reissman (1993) calls ‘thematic coherence,’ as they appeared over and over again in the interviews.

Thematic content analysis was undertaken, drawing on the approach described by Rosemarie Anderson (2007). Codes derived from the interview text were used to label sections of the text (‘meaning units’) and the theme that they represented highlighted on the transcript. For example, responses that denoted an indication of human specialness were assigned the theme of death as, according to TMT, beliefs of human specialness indicate a need to be distinct from other animals and recognize our mortality (Goldenberg et al. 2001). Evidence of meaning making during the interview, in response to the ideas discussed, was generally assigned to the theme of meaninglessness, whilst established forms of belief that the interviewee brought to the interview were assigned to the theme of responsibility as they indicate personal meaning making; however, the distinction is not always clear and meaning making could also be interpreted under the meaningless theme. There was a degree of overlap between the themes as they are not discrete and at times multiple themes were assigned to a meaning unit or block of interview text.

Findings

For reasons of conciseness only the findings from the third level thematic analysis of the eight core interviews are presented here. For the full findings see Newall (2021).

Identity and death

The theme of identity was often invoked in the responses to the ape portraits. Paul and Patrick expressed similar issues with these images, being suspicious of the motives of the photographer. For Paul, for instance, human identity is highly specific. Paul’s position was that humans understand the world through language; since animals have no language, we cannot claim any knowledge of the animal experience. The interviews with these two young men indicated the personal importance of ‘being clever,’ an academic identity claim which, when considered in the context of their responses to the ape portraits, is indicative. Both Paul and Patrick describe how they are not comfortable with the manner in which they consider the apes are depicted in the photographs. “My problem is the humanisation of them.” (Paul). Their reasons for this discomfort mirrored some of their earlier responses; they drew on philosophical interpretations, in the case of Paul, and sociocultural, in the case of Patrick. These responses reflected their academic identity claims and allowed them to examine the portraits at an emotional distance.

An indication of defense was in Paul’s justification for his stance. He emphasized a position based on an intellectual standpoint, rational, educated thought, which came from his interest in philosophy and semantics. His emphasis throughout was on the importance of rational thought; this was fundamental to his worldview. Intellectualization, and similarly rationalization, is potentially a defense. Intellectualization is far from uniformly described, defined or accepted in the literature, which makes it even more difficult to apply (Arnold 2014). However, Arnold describes it as “the translation of emotional material into intellectual terms” (Arnold 2014, p.630). It was described by Anna Freud in her work with adolescents and is seen in the wider literature as “a defense against affective experience or affective modes of activity” (Kestenbaum 1983, p.673), although the relationship between cognition and affect is disputed and complex. Anna Freud did not see intellectualization as “A flight from drives” but “a turning toward them in thought” (Freud, A. in Kestenbaum 1983, p.677).

Patrick’s response to the ape portraits showed similarity with Paul’s but from a different standpoint; he perceived them as anthropomorphic and was unhappy with this. He felt that the photographer was making the apes appear more human, that he, as viewer, was being manipulated to feel sympathy and then to take action; in his own words, “I imagine under a lot of these pictures was ‘please give now.’” Like Paul, Patrick was potentially missing something; he was seeing how these apes are like us, but was not thinking about how we are like them. Patrick’s conversation throughout revealed his wide reading and his deep thinking on political and social issues. Like Paul, he seemed to be retreating to an intellectual stance.

In summary, both Paul and Patrick expressed a problem with seeing the human in animals. Ernest Becker proposed that we deny our creatureliness because this highlights our corporeal nature. If we are organic beings, it therefore follows that we are vulnerable, mortal. We distance ourselves from our animal selves to deny death; hence, here identity overlaps with the theme of death (Goldenberg et al. 2001; Becker 2007). What was interesting is that in all descriptions the interviewees gave of the portraits, the language indicated a recognition of the resemblance of the apes to humans, but never were humans described as resembling the apes, another possible indication of a defense against our animal identity.

In the video, Dhruv saw instability of identity, drawing on science fiction, creatures that can “transform into anything,” impermanence, illusion. The inference was—can you believe what you are seeing? Is the creature what you think it is? He found the ape photographs threatening: “they are looking right at you and you know that they are powerful beasts, you know that they are dangerous and

so I feel defensive.” Dhruv, who was outwardly alarmed by the ape portraits, and saw aggression in the apes’ faces, regardless of the absence of a real threat—a psychic projection of another fear. Again, death as a theme emerged through discussion of human identity.

Language used in the interviews also often indicated discomfort at the instability of human identity, with fears expressed for the next stage of human evolution. “Yeah, there is growth and there is over growth. Like if it is we have evolved from fish are we going to carry on evolving? Will us humans evolve into something else? That’s worrying.” (Jane) Some respondents also seemed unconsciously to personalize evolution in their descriptions, for example, “so you had to stumble through these, you had to be a fish, you got to be a human.” (Patrick).

Time and death

Time was the most frequently expressed existential theme in response to the timeline and the video. Both visual prompts represent time in some way and imply a direction. Time seemed to saturate the interview narratives at times. It was noticeable in the interviews how participants’ descriptions of time were sometimes odd, even contradictory at certain points. Common expressions of time as a theme were via expressions of a fear for the future—personal futures, loved ones’ futures, and the future of humankind generally and, like identity at times, connected to the theme of death. For Rosie, time was expressed through anxiety over potential change and looking to the future: “which direction is the world going to go now?”

Dhruv’s reflections on time were associated with ideas about the uncertainty of the future, science fiction and the insignificance of the scale of human time compared to the incomprehensible vastness of time on a universal scale. Dhruv had considered time in the depiction of evolution in the timeline. In his mind, he had no notion of anything before the existence of the dinosaurs. He struggled with the idea of time on an evolutionary scale:

Dhruv: that is surprising. That would change what I thought initially. Yes, that is surprising. And I would remember that. I guess if I saw, were told about how many years ago the dinosaurs existed, that is numbers, and then you can compare it to, I don’t know, when there was first life on Earth, you could compare the numbers and then go ...

Emma: but it’s very abstract, isn’t it?

Dhruv: you can’t have an appreciation of it.

Emma: no.

Dhruv: because the relative thing tells you a lot.

He went on to consider time in the future:

Dhruv: it felt futuristic, as if I am looking at something that is going to happen in the future?

Emma: well, this might seem like a strange question. How does it make you feel? Not just the image itself, but also what we have discussed about it. Do you feel anything? Do you have any emotion?

Dhruv: insignificance because we have only been here such a short time. But then, yeah, insignificance, and time is this big scary thing.

The timeline made the future explicit for Dhruv:

Dhruv: it makes me think about the future, how we are going to evolve and how human life will change, but it feels a bit scary at the same time. My mind is blank. I don’t know what is going to happen. I don’t know if that is because there is almost like a cliff there.

So, time being finite is associated with the existential concern of death and therefore may trigger anxiety. Certainly, death was often the existential concern associated with time in the interviews. It was also often associated with origins. Jane wanted to know “who was the first person?” but then her concern turned to what will happen next:

Jane: ... are we going to carry on evolving? Will us humans evolve into something else? That’s worrying. Not knowing, not knowing what could be in twenty years. What our children could be faced with.

Twenty years is insignificant in the evolution of humanity. It was as though the timescale involved in the processes of macroevolution, the sheer number of years, is not just incomprehensible, but disturbing, unsettling, not amenable to human thought.

Jane, Patrick, Rosie and Susan all focused on the fact that there was a huge period of time in evolutionary history when humans did not exist. Jane described there being “nothing,” then “life,” “nothing,” then “something.” Patrick noted that the timeline was at first “empty” then “full.”

Jane was ambivalent at first, then saw improvement in the timeline: “So yes, it is a form of growth I think, evolution you could say is getting better as it goes on.” However, when asked how she felt about it, she explained how she felt both positive and negative about it:

Jane: well, the positive side of it is, you can see there’s not much life, not much going on at all here and as we go further in things are starting to evolve, from where I have no idea, and then as you can see it is, more life. But then look at this bit. I can see that we are going from some nice quiet areas (laughs). Looks lovely, you know there’s not much human activity

going on and then it starts to get crazy and visual nuisance. There's lots and lots of stuff happening, it is happening more and more, it increases as we are going further and then it seems like lots of tech, technology you can seem you've got the buildings. I live here now so I know what it is like, I didn't live, I weren't alive here.

Emma: and how do you feel about what it is like?

Jane: I don't know, I don't know if it is positive or negative, but we are kind of with all of our technology kind of taking away this part of what we have got, you know this bit.

Emma: do you mean the natural world?

Jane: yes, I feel slightly worried.

Jane's reaction contains some disquiet, but it was tempered by her acknowledgement of a kind of human progress. Freud considered ambivalence as a state where both love and hate could be felt for the same object (Freud 1955). Jane is ambivalent toward human progress, toward a changing world. Evolution implies change but of an unpredictable nature. For her, the implications of what the timeline represents is possibly worrying.

For Rosie, time was expressed through anxiety over potential change and looking to the future: "which direction is the world going to go now?" On showing her the timeline, Rosie also described the early periods as "empty" but like Jane thought of what follows as growth. Her tone changed when she noticed the position of humans in the timeline. She was asked if she noticed anything that surprised her and she responded:

Rosie: It is quite surprising how, how just, how late we actually got to play in the whole evolution game. We are just right at the end, they all had fun before us. It's a bit unfair isn't it ... I keep forgetting how much evolution happened before we came along. It always surprises me over and over again how much happened before we got here.

Rosie went on explicitly to voice the anxiety she seemed to be hinting at: "It's quite a bit scary, there's a lot at stake, because the dinosaurs they have gone now." Death as an existential concern was explicit; the simple line drawing connected with a frightening idea. Nothing is permanent, humans are vulnerable; one day we may no longer exist. Or more personally, one day 'I' will not exist.

Death and human specialness

In terms of defense, some people's responses indicated a wish for or belief in human specialness. For Melanie, this was expressed through both the themes of death and through a need for human specialness at several points. When talking about the timeline Melanie said "It is the

evolution of human beings." On watching the video, she responded:

Melanie: It is basically looking at the evolution of man ... Evolution because clearly it's the formation of man, and to me it's the evolution of man, but also because part of me likes the idea of Intelligent Design.

Jane's responses to the timeline were dominated by the theme of death. Early on in time she saw "not much life;" she commented, "I didn't live, I weren't alive here," then a loss expressed through change: "it is such a new change from nothing to such a mass of things going on now." In the video she begins to question "is it possible we evolved from a fish?" and "who was the first person?" This was followed by thoughts on a world without people, with non-existence as the ultimate death:

Jane: Yeah, there is growth and there is over growth. Like if it is we have evolved from fish are we going to carry on evolving? Will us humans evolve into something else? That's worrying.

Emma: Why is that worrying?

Jane: Not knowing, not knowing what could be there in 20 years. What our children could be faced with.

In Rosie's responses she notices parts of time that are "empty," but also is surprised by how far down the timeline humans appear. She comments "It's quite a bit scary, there's a lot at stake, because the dinosaurs they have gone now." It seems that death of the dinosaurs potentially acts as a death equivalent, eliciting anxiety.

Under the theme of death, Susan considered human survival, and was perplexed and unsettled by the idea that there was a time when humanity did not exist. This was an idea she found hard to grasp but when we discussed how humans emerged through evolution from earlier species, in that way they seemed to have always existed for her. This was something she found reassuring.

Dhruv moved between expressions of human specialness to human insignificance and powerlessness; he also talked about the instability of human identity, the possibility of our transformation into other forms. He saw the ape figure in the video and those in the photographs as threatening, with malevolent intent. When faced with the ape photographs he made very human assumptions about the animals depicted:

Dhruv: They look like they are really smart and they look like they are planning something and they look like and, you know, that they are dangerous the way they can move and actually some apes are supposed to be three times stronger than men. But then at the same time it feels like there is a bit of a stone

coldness, so there is intelligence but they don't have human values.

This anxiety provoked by their uncanny similarity but also their difference is expressed at a need to both compare apes to humans but also to distance us from them. Our separate identity as a special group is important to him. Here death also overlaps with identity.

For Zara, death was mostly expressed through loss, that being the consequence of a significant childhood incident when her faith and trust in adults was challenged. Death is also expressed as a theme of the meaning units concerned with our relationship with apes and meaning, as she questions “why are some apes still apes?” and “why haven't humans evolved yet?”

Human specialness is clear in her ambivalence to our similarity to the apes which is understandable, given her creationist beliefs:

Zara: Again, they make me think about the fact that scientists say from theory, that we have some sort of connection with them. And I can see from looking at the close up that if you look really carefully you can see some sort of resemblance.

Meaning(less) and responsibility

The two themes of meaning/meaningless and responsibility are presented together as they overlap greatly.

Paul seemed to be comfortable with the tentative nature of scientific and philosophical explanations and he was not obviously discomfited by the unpredictability of the future. Paul's acceptance of ambiguity may be a reason he is not uncomfortable with evolution as an explanation, an idea with uncertainty at its heart, and does not see evolution as implying meaninglessness. He expressed responsibility through his own personal meaning system that was not challenged by the idea of evolution.

Melanie, although describing herself as agnostic, created meaning that drew on her Christian upbringing. She described the video as reminding her of Intelligent Design. She described the video artist as sketching, revising, creating. This idea appealed to her because she wanted “to hold onto this great idea that there is something more, something greater.” She wanted to see evolution as the how not the why, as a process of creation with humans as the end product, using the metaphor of the sketchpad, the variety of life is “just different sketches.” She was highly consistent in what she expressed. She had a well-formed personal philosophy, that of connection and the interdependence of lives, and human specialness, but she was still looking for meaning.

Concerns regarding both humanity's origins and endings were often evoked by the timeline and video,

challenging existing senses of meaning. Susan remembered “battling with that concept that we came from an ape.” She was seeking answers in response to both the timeline and video, as she said struggling with the “many possibilities ... the different perspectives that they say made the human.” She was looking for meaning externally: “I know that there is not always an explanation but for something as important as to how we came there has to be an explanation.”

Patrick strongly expressed a personal sense of meaning. This was through an active negotiation during the interview on the nature of existence as he saw it; he took full responsibility for this and rejected the idea of relying on external agents to derive meaning from that existence; he owned his own world. On examining the timeline, he asserted this position, criticizing the timeline for implying there is a plan to evolution, with humans being the end point.

For Dhruv, meaning was only strongly expressed when he described his upbringing as a Jain and how, although non-observant, he still believed in many of the values of Jainian philosophy. However, talking of the timeline, meaningless was invoked as he spoke of “Insignificance, because we have only been here such a short time. But then, yeah, insignificance, and time is this big scary thing.”

Isolation

Isolation was not a frequent theme of the interviews, perhaps as evolution is associated with biological relationships and the interconnectedness of life. However, there were points when it possibly emerged. Patrick's insistence on making sense of his own world in his own terms broke down a little when he looked at the video. At first he resisted interpreting it, but then revealed that he saw vulnerability in the man, which could be interpreted as falling under the theme of isolation; the human appears from the ape, naked and to Patrick looking vulnerable:

Patrick: Like at the end, towards the end when the face starts to appear and stuff, the more human face, the guy looked very uncomfortable. I mean I would too if I was naked and on film. It looked very dark and I suppose it wasn't a happy video, it wasn't nice. It felt like it was supposed to make me uncomfortable.

Susan was happy with having animal origins; what did concern her was the when, the timing. Why did we appear on the timeline when we did? That means there has been a time when humans did not exist; this was disturbing to her. However, the video implied that we came from other animals, from fish. To Susan, this meant in some way that we did always exist, which in turn was reassuring. This

was an intriguing response; we had anticipated the possibility of hearing discomfort at animal origins, but Susan's anxiety was centered on a previous non-existence which was ameliorated by our connection to our animal ancestors. An isolation neutralized a biological relationship.

Melanie saw the video as the story of us, human beings; it is "the evolution of man." She viewed the artist's depiction as one of connectedness: "we did form from other beings ... we are all connected, everything is connected." So, for her there was the opposite of isolation.

Discussion

This article began with a summary of the common non-scientific assumptions that many people have about the natural world, such as evolution being individual transformation (Bardarpurkar 2008), and intuitive beliefs about nature, such as essentialism or goal-directed (teleological) thinking (Kelemen 2012). The purpose of this research was not to investigate such misconceptions but to look for evidence of existential concern in response to evolution. What is notable in the observations of this study is that ideas such as human transformation may provoke anxiety. Consider the responses of Dhruv to the apes and Jane's anxiety over the future of human evolution. In addition, challenges to essentialist and teleological thinking may cause discomfort or may be seen as a refuge in the face of potentially alarming ideas. This can be understood through the framework of existentialist thinking, particularly where it meets psychoanalytical theory and existential psychoanalysis.

Martin Heidegger described the experience of groundlessness, when our everyday understanding about the world is challenged, when we become aware of our *being in the world* (Heidegger 1927/2010). Heidegger saw our everyday existence as an all-consuming preoccupation with normal life. The result of this is that sometimes we have an experience where our being in the world or our place in the universe is revealed to us. We become acutely aware of our existence as separate and distinct from the world. This can produce a sense of the uncanny, the no longer being at home in the world, groundlessness. The results of this study, we suggest, indicate that for some people evolution, particularly the possibility of human evolution and our relationship to other creatures, may produce this experience. What is notable from previous research on teleological and essentialist thinking is that such intuitive thinking is more likely to be relied on in potentially stressful, for instance, time-limited situations. Therefore, is the anxiety, even if only mild, potentially engendered by evolution itself inducing this intuitive thinking? Further research needs to be done to explore this but we propose that there is evidence that some people may have an adverse emotional response to evolution

that is not associated with religious beliefs and that could be explained by existential concern. Four of the analytical themes we discuss—death, responsibility, meaninglessness, and isolation—are what Irvin Yalom (1980) calls the ultimate concerns about existence. Yalom considers these concerns to be part of the groundless state described by Heidegger and provoked by what Yalom terms urgent experiences, such as challenges to how we see and experience the world.

Irvin Yalom (1980) also suggested that a need for personal meaning centers on the issue of transience, a concept implied by evolutionary change. As Rosie remarked, on considering the implications of the timeline, "It's quite a bit scary, there's a lot at stake, because the dinosaurs they have gone now." If we vanish, how can our lives have meaning? How more desolate is this even than the realization that all humanity is likely to be doomed to eventual extinction? This is what evolution implies and regardless of timescale we need to create meaning to counter this idea, to neutralize transience.

Time as a concept is central to Heidegger's writing on existence and it was a key theme in the interview data. The relevance of time for evolution is clear: Geological time can be unfathomable, feel unhuman, just too vast to grasp. Evolution challenges us to think about time and our existence. Time also represents a paradox existentially. First, consider Freud's thoughts on time; he thought of the unconscious as timeless (Freud 1915). Timelessness suggests there is no before and no after, no past nor future. This implies unpredictability. Temporality confers some level of predictability, of control, a direction (Parsons, 2009). So, timelessness may represent chaos, like a dream where meaning is obscured. The timeline therefore may represent order and confer some meaning to existence, particularly if you see what as having a direction, a purpose—namely the creation of human beings, as was the case for some of those interviewed.

However, temporality also suggests the finite, death and its attendant anxiety. Historically, there was a time when we thought ourselves at the center of the universe and that the skies represented an unchanging eternity, but "the discoveries of Copernicus and Galileo brought an end to this way of thinking about nature ... we still hunger after evidence of the unchanging and timeless in our otherwise mutable universe" (Hanly 2009, p.22). Hence, time is problematic in both its absence and its reality. We may need to feel grounded in existence, but we want to avoid the implication that for us individually existence is finite.

Another aspect of existential concern is that provoked by our relationship to non-humans. The idea of mortality salience proposed by terror management theory (TMT) is also helpful in understanding the responses of some of

the participants in this research. Mortality salience refers to an awareness of our own inevitable death and that anything that reminds us of our mortality, even if indirectly, can provoke psychic defenses. One such reminder is that we are biological beings vulnerable to the laws of nature (Becker 2007). This is expressed by participants through a belief in human specialness. Also, returning to the ideas of Kahneman (2003), reminders of our own corporeality highlight our mortality and may provoke intuitive or system 1 thinking. Again, there needs to be more research carried out into our attitudes to other animals and our biological relationship to them, but these findings suggest that existential associations with corporeality and death could influence our perspectives on our place in nature and our potential relationships with other animals through evolution.

The potential of this research design

The cyclical nature of the analytical approach, with its three levels, allowed us to refine the earlier themes of human significance, change and identity as animal after data collection, and led to theory building around the impact of existential concerns on people's affective responses to evolutionary concepts. The themes of time, identity, death, responsibility/freedom, meaninglessness and isolation exposed existential concerns in the interviewees. The themes of time and death were most frequent. Death or fear of death as a theme emerged directly at times but more often indirectly through death equivalents. This was, for example, through acknowledgement of a time when humans did not exist or the end of the human species through evolution, but most often through an expression of human specialness, an exemption from natural laws. Evidence of personal meaning for participants in the ideas discussed and active meaning making were also common.

The interviews could suggest that, in some cases, we cannot but help seeing the evolution story as about us, even if we also reject this idea. It is our past and our future. Jane, Rosie, and Patrick personalized evolution. For Melanie, the timeline was all about us: "It is the evolution of human beings." Melanie drew on this idea of human specialness which, according to TMT, is an attempt to evade reality, the implications for life, struggle, and death in the march of evolutionary time (Goldenberg et al. 2001). Existential psychoanalysis describes forms of secular personal meaning as fulfilling a human need to believe that there is pattern and purpose in life, with goals to fulfil and roles to perform. Evolution is known to attack cosmic meaning systems; this is a potential basis of religious objections to evolution. Cosmic meaning infers a supernatural source, so refers to faith-based

meaning systems. Responses such as Melanie's suggest evolution could also represent a personal secular personal meaning. The framework of existential psychoanalysis has proved an effective means of exploring existential responses in the absence of religious belief and allowed an exploration of non-faith-based emotional responses to evolution (Yalom 1980). The results of this research indicate that such a framework could be useful in exploring negative responses to evolution beyond those examined in the context of religious faith. It may even be possible to go on to consider why not all people with strong religious convictions object to evolution. Perhaps existential concern could be responsible for resistance amongst religious individuals also.

Ultimately, we argue that existential philosophy and Terror Management Theory can provide some explanation for the elicitation of these themes in response to the prompts used in the interviews. Existential thinking argues that we are not supplied with a meaning system; the universe is indifferent to our needs and as moral creatures we need to create our own meaning, to supply our own values (Yalom 1980). Evolution may challenge some of those values, both secular and religious.

Limitations of the study

This was a small-scale study of a group of people with a professional interest in education. Both of these features mean that it is not possible to generalize from our interpretations of this group of 17 audio-recorded interviews. In the interviews, EN was also always open about her research interests and this may have caused some bias in the responses to the stimuli that were presented. The stimuli themselves could also by their nature point towards certain ideas. It might be objected that the visual prompts we used elicited participants' emotions not because of their evolutionary content, but because of their artistic content. In response we would ask why some of the content was found to be uncomfortable. Our argument is that the material that is uncomfortable is uncomfortable for reasons that are to do with such things as the break-down of the barrier between humans and other species. We note that some participants, for instance Paul, did not find the content of the video uncomfortable. Indeed, he said that he loved it.

Implications for teaching the theory of evolution

Our findings, and the discussion of these, indicate that the simple answer to our research question: Do certain concepts implicit in the theory of evolution, such as change, extinction, the vastness of geological time, and humans as animals, provoke affective existential responses in some people? is 'yes'. How then might a

teacher with school or college students or a teacher educator respond to such student concerns? We suggest that there is much to be said for considering evolution as a ‘sensitive issue’ when teaching students for whom religion raises existential and/or religious concerns. Evolution is also a conceptually demanding topic, and this needs to be born in mind by those teaching it.

There are a number of advantages in considering the theory of evolution as a sensitive issue (Reiss 2019). For one thing, while many biologists don’t like evolution being considered as a controversial issue (on the grounds that the theory of evolution is not scientifically controversial), there seem to be fewer or no objections to considering it to be sensitive. Then there is the advantage that as humans most of us are quite good at knowing, almost automatically, how to behave when dealing with someone for whom an issue is sensitive (think a bereaved friend or colleague, or someone worried about their sexuality or how they are going to admit something embarrassing or whether their country should go to war): we are careful with our language, more tentative in our speech, more alert to the possibility that the other person may be upset by something we say or some feature of our non-verbal communication. With certain exceptions, it seems that most humans are better at dealing with issues that have associated emotional impacts than they are at dealing with rational arguments.

There is quite an extensive literature associated with the teaching of sensitive issues, though not all of it is directly applicable to the classroom (Reiss 2019). Duffee and Rosenberg (2009) discuss how college-level courses that focus on ‘social problems’ (e.g., domestic abuse, shootings on campus) can “evoke a wide range of responses from students—including shock, disbelief, anger, tears, and/or depression—that can even compel some students to physically leave the classroom” (p.104). They discuss the value of paying careful attention to the course materials that are used (so that, for instance, they do not objectify individual victims or marginalized groups), discussing ground rules for class discussions at the start of the course, helping students access sources of support and help, and listening attentively to the stories (often autobiographical) that students tell.

Although we are unaware of any systematic evidence that evolution be considered as a sensitive issue, Asghar et al. (2007) found that about 22% of the pre-service teachers in their study viewed evolution education as a ‘delicate’, ‘sensitive’ and ‘touchy’ matter. Taken with the findings reported in this article, that suggests that treating evolution as a potentially sensitive issue (i.e., sensitive for some learners) may make good pedagogical sense.

We therefore end with some bullet-pointed suggestions that follow from our study for educators when teaching about evolution:

- Educators need to be aware of and, so far as they can, understand their own feelings and responses to evolution.
- Educators should consider what they might be communicating unconsciously about evolution to their students.
- In addition to explicitly acknowledge the emotional difficulties that the topic of evolution may elicit in some of their students, educators should continue to address misconceptions that may contribute to existential concern. For example, a certain amount of clarification and reassurance that evolution is not something that threatens us individually but explains the history of life on Earth may be helpful.
- Educators should consider the value of treating evolution as a potentially sensitive issue (i.e., sensitive for some learners).
- Educators should provide a supportive environment for those of faith that does not suggest that students need to choose between their faith and acceptance of evolution. This final suggestion is included despite the focus of this study not being on the role of faith, as existential concern could be at the heart of many negative responses to evolution, including those usually attributed to religious beliefs. This is an area that warrants further investigation.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12052-023-00183-9>.

Additional file 1: Interview guide and schedule.

Additional file 2: Interviewee characteristics.

Additional file 3: An example of the second level of analysis for one interviewee – Patrick

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Author contributions

EN: Conception and design of study, data interpretation, manuscript authorship. MJR: Supervision, manuscript authorship. All authors read and approved the final manuscript.

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Competing interests

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