The Influence of Animation to Display Themes of Childhood Nostalgia in Narrative Storytelling

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ABSTRACT

Themes of coming-of-age and childhood nostalgia may have strong influences when developed inside the animation medium under narrative storytelling. We interact with various animated works in our childhood such as animated movies, cartoons, and advertisements. Showcasing a theme in a narrative story that revolves around childhood nostalgia and coming-of-age may elicit strong emotional responses due to our recollection of various animated works within our childhood. This paper will discuss how using tools inside the animation pipeline can help artists and animators create powerful, emotional responses within characters, expressions, and environments through thematic elements in narrative storytelling.

I. INTRODUCTION

In narrative storytelling, using an animated medium may have strong influences on displaying themes of childhood nostalgia and coming-of-age in narrative storytelling. These are thematic elements often present in films and television shows, especially in the animation medium. As this theme doesn't target a specific audience, it can shift between all age groups since everyone experiences this change as they grow older. As children, we are exposed to many animated works in films and television shows. Cartoons, children's books, and colorful advertisements are all examples of animated works we interact with in our childhood. The animation medium may offer a powerful, impactful emotional display of themes relating to our childhood such as nostalgia and coming-of-age. The animation medium can be used to communicate emotions and visuals in stylized ways. Conveying themes, ideas, and unique visuals within the animation medium create more opportunities for creativity when exploring these different areas. Morphing the face of an animated character in unconventional ways becomes a possibility such as the infamous portrait of the "smiling Grinch" in How the Grinch Stole Christmas (1966). The exaggeration of body movement can be produced such as the motion blur in the Roadrunner character sprinting through the frame in various Looney Tunes (1930) animated shorts. Animators can create stylized scenes that go beyond normal human locomotion and expression to help convey their ideas to audiences. This paper will discuss how using tools inside the animation medium can help artists and animators convey thematic representations of nostalgia using stylized characters, expressions, and environments. Subject areas surrounding child psychology and animation will be observed to determine how influential animation is on children and the themes of childhood nostalgia and coming-of-age. The discussion will conclude with how animation can contribute to thematic storytelling surrounding one's childhood and the future of narrative storytelling using the animation pipeline.

A. The Problem

The problem lies within the level of emotion people feel when watching animated characters embrace themes of childhood nostalgia and coming of age. The animated medium can be used in many different styles. Sometimes, a distinct art style can heavily affect how character emotion can connect with an audience. If characters aren't showing adequate facial expressions and proper dialogue, a character can become boring and uninteresting. Using unique art styles can influence that. For example, if you're creating an animation with a photorealistic art style with photorealistic characters, you may feel limited when animating emotion. In this style, you can't exaggerate facial expressions, morph body parts, or follow most of the other principles of animation. You're limited because of the art style, and sometimes, that can have an impact on how well a character is emoted in a story. Emotion is one of the key factors of telling a good story, and without it, the characters can't connect with the audience, and therefore, become stale. When using a different art style, such as colorful and stylized, there's more opportunities for you to exaggerate character movement. You can stretch the face and morph the body into stylish poses. This can exact more opportunities for character emotion, which in turn, can create better characterization. This study discusses if animation can be used as an effective medium to show themes of childhood nostalgia in narrative stories because it will help artists and directors understand how emotion can be more powerful and convincing in animated storytelling.

B. The Purpose

This significance of this paper is associated with many different factors within the realm of animation and can be applied to multiple areas of animation, game design, and VR. Some studies have proven that virtual environments with animated characters and facial expressions can be a useful tool in medical training when working with patients (Anolli, Vescovo, Agliati, Mantovani, & Zurloni, 2004). Sometimes, a human-robot relationship can be better and more effective than a human-human relationship. Another reason is the effect of color on emotion. According to Daniel Oberfeld and Lisa

Wilms (2015), bright and vibrant colors can influence how powerful an emotion can be. Brighter hues can cause a more intense emotion while saturated colors can do the opposite. This can be applied to animation where style is important and including many different colors and vibrant hues can bring out emotion even more. According to McDonnell, Breidt, & Bülthoff (2012), when participants compared a stylized character to a photorealistic character, they didn't notice a huge difference between the two. The participants were asked to pay attention to certain tasks the characters were doing and, in the end, noticed an equal number of things the stylized character was doing compared to the realistic character. This tells us that photorealism can convey the exact same information (movement-wise) when compared to a stylized character. However, the participants rated that the stylized characters were much more visually appealing and appeared more friendly than the photorealistic characters when large motions were present. Because of this, if you're trying to make a stylized character emotional, the audience will sympathize with it more because the character will seem more friendly and innocent, therefore, enhancing the emotion.

II. REVIEW OF LITERATURE

Because the problem relies in the strength of the emotion, multiple factors need to be taken into consideration when conducting a study that deals with emotional responses. Many factors such as lighting, body language, color, and shading can influence the emotional response of the participant. There have been many studies that have looked at these factors and how they affect emotional responses from participants. Looking at databases known for animation research studies can help better understand what research other people have done relating to emotion in animation. ACM, The Animation Journal, and the Animation Studies Journal are examples of databases which would have these research studies. Concepts related to shading, lighting, color, and body language will have to be looked at to determine what factors to keep consistent. Similar statistical analyses will also be looked at.

A. Findings Pertaining to the Problem and Purpose

The literature includes various studies on character emotion and how factors such as light, shadow, and color influence emotional response. Celso de Melo and Ana Paiva (2007) talk about the use of light, color, shadows, and filters to convey emotion rather than dialogue and body gestures. This is important because lighting is one of the most powerful tools in filmmaking to convey a character's emotion. The study concluded that using lights can be an effective way to show emotion and can help intensify what emotion you're trying to express. In an animated film, you have total control of the lights and shadow, and you can use that to your advantage to express more powerful emotions within characters. Rachael McDonnell, Martin Breidt, and Heinrich H. Bülthoff (2012) talk about using different art styles to convey information to people. This is important because photorealistic CG characters can sometimes become awkward and uncanny, according to audiences, in video games or movies when showing character emotion or conveying basic information. The study tested a stylized art style and a photorealistic art style and asked participants to focus on certain tasks animated characters were doing. The participants were asked to pay attention to certain tasks the characters were performing and, in the end, noticed an equal number of things the stylized character was doing compared to the realistic character. This tells us that photorealism can convey the exact same information (movement-wise) when compared to a stylized character. However, the participants rated that the stylized characters were much more visually appealing and appeared more friendly than the photorealistic characters when large motions were present. Because of this, if you're trying to make a stylized character emotional, the audience will sympathize with it more because the character will seem more friendly and innocent, therefore, enhancing the emotion.

Aryel Beck (2011) talks about the use of body language in animated films to show emotion. This is important because emotions have a strong influence on how audiences connect to a character, whether it's through medical training or an animated story. In live-action films, human body language cannot be exaggerated like animated characters, and this study tested if there was a difference in recognizing the expressed emotion because of that. They concluded that there is not much of a difference in recognizing emotion conveyed through body language in animated and realistic characters. However, they found there was a difference in the strength of the emotion, saying the emotion was stronger in the animated character compared to the realistic character. This could possibly be applied to facial expressions as well. This study talks about the use of shading in animated characters to show emotion. Shading is important because lighting and rendering is one of the most important tools in conveying emotion to an audience. Pisut Wisessing, John Dingliana, and Rachel McDonnell (2016) wanted to see if participants were able to recognize the emotion of the character depending on how the character was shaded. They concluded that there wasn't a difference in recognizing what emotion the character was showing depending on the shading. However, there was a difference in recognizing the intensity of the emotion, saying that toon-shaded characters showed less intense of an emotion compared to a CG-shaded character. This is similar to the study above, saying that there isn't much of a difference in recognizing what emotion it is, but there is a difference in recognizing the intensity of the emotion.

Anolli, Vescovo, Agliati, Mantovani, and Zurloni (2006) talk about the significance of character emotion in medical training. In medical training, sometimes a virtual character is used to help the patient comply with certain medical treatments and using a virtual character with animated expressions can help immensely with that. A virtual character can also be much more intimate than a real person so using a human-robot relationship instead of a human-human relationship can also be beneficial. Daniel Oberfeld and Lisa Helms (2015) talk about the significance of color being used to control the power of emotions. In this study, it was found that brighter and more vibrant colors affect people's emotional state and resulted in higher arousal. Colors with a more intense hue turned out to convey a more powerful emotion than colors that were more saturated. This can be

applied to stylized media where character emotion plays a big part of a story.

B. Summary of the Review of Literature

The sources found give a good understanding of the other factors involved in character emotion. Using these sources, studies can be created that keep these factors consistent throughout. These sources discuss how emotion can be better or worse in animation depending on the art style. From these sources, many problems arise that revolve around character emotion in different animation art styles. All these sources come from research studies done at universities or another credible institution. Each source includes extensive detail in the abstract, research methods, and conclusion, which is going to be helpful for creating a design project.

III. ANTHROPOMORPHISM

Anthropomorphism is giving human traits and characteristics to something that isn't human. For example, in the Pixar short, *Luxo Jr.* (1986), the two lamps are treated as if they were a parent and a child. The lamps nod their head and convey emotion even though they don't have facial gestures. All this emotion is conveyed through animating body movements. Because of this, we feel attached to these characters. We feel as if they are human. One of the major advantages of animation is being able to morph objects in unconventional ways. The ability to squash and stretch objects can be used to make different shapes that would otherwise be impossible to do in live action. In a study done by Jung Min Lee, Jongsoo Baek, and Da Young Ju (2018), participants were asked to choose what emotion they felt when looking at different shapes (Figure 1). The shape which most people thought conveyed happiness were the shapes that bent on the horizontal axis in a convex manner. The shapes which were bent over on the horizontal axis were thought to convey sadness and the shapes which were pointy and bent over on the diagonal axis were thought to convey anger and disgust. Another subject that can be related to anthropomorphism is iconography. Iconography is the simplification of complex

Fig. 1. Shapes used to ask participants what expressions were being conveyed.

images into smaller, more basic shapes. For example, we can draw two circles and a curve to create a smiley face. Even though there are only three shapes, we can still see resemblance of a human face. We can also see this in technology, specifically robots. Robots don't have facial gestures but can still share a form of empathy with another human. In a study done at the Technical University of Lisbon (2011), a robot was built to show empathy to a person playing chess and losing. The study compared two robots, a robot showing empathy and a robot showing no empathy. The robot that showed empathy turned out to have a more positive effect on the person's companionship, intimacy, and emotional security. Another medium with limited facial expression is puppetry. Jim Henson's hugely popular Muppets are very recognizable characters each having a unique personality. Even though they're puppets, we can still tell what emotion they're feeling through the voice acting and the body gestures. The design of their character helps further the appeal. Though, you do still lose some of the facial expression because they're puppets and they can only move their eyes and mouths in so many different ways. In fact, one of the big critiques from *The Dark Crystal* (1982), another movie where all the characters are puppets, was that the characters didn't show enough facial expressions. The visuals looked good, and the puppetry was impressive, but the characters didn't show much emotion in the face. Still, it's a very rare artform, and the audience appreciates that. The audience knows they're watching puppets, and because it's something rarely seen in film, they appreciate it more than usual. In *Puppetry in Education and Therapy: Unlocking Doors to the Mind and Heart by Matthew Bernier and Judith O'Hare* (2005), puppetry is an artform used to help social and communication skills. They talk about how puppets can be used to better communicate lessons in focusing and empathy. For example, puppets can be much easier to talk to because there's less of a barrier between you and a fictional character which creates a more intimate connection. Fred Rodgers was infamous for using puppets to teach children about important life lessons, some of which were very tough to talk about such as murder, divorce, and death. All of this can tie back to iconography and how we can humanize simple objects such as robots and puppets. Though, if you're making a film and need to show more complex facial expressions, then animation might be the medium to use if you're having trouble getting certain motions and expressions in the real world.

IV. ANIMATION VS. LIVE ACTION

When making an animated film, there is almost always a reason for choosing to do so over live action. In animation, there are endless possibilities in terms of imagination and creativity while live action films are limited to anything that can be accomplished in real life. Today, we have an overabundance of visual effects used in live-action films so the possibilities of creating something from your imagination can most likely be done in live-action films now. However, animated films are still made, and most of them offer a certain type of creativity that would otherwise be difficult to obtain in live action. In animation, you can morph your objects by squashing and stretching. You can easily create colorful settings and bubbly characters. You can easily exaggerate

certain movements that would be impossible for a human and you can create metaphors that would be difficult to achieve realistically. This advantage over live action allows artists to express certain themes more creatively. In live action, you're limited to your surroundings and sometimes the artist may need a certain setting that is difficult to attain. Another big advantage of animation is facial gestures. Looking at *The Lion King,* the 1994 animated version and the 2019 photorealistic version, we can see that artists were limited in the photorealistic version. In the animated version, you can easily obtain exaggerated expressions and colorful musical sequences. However, in the photorealistic version, a real lion's expressions cannot move the same way the animated versions do, so you lose some of that expression in the character.

A. Photorealism

Fig. 2. Live action classroom and virtual classroom used to ask participants which student they found cheating on the exam.

However, live-action films have something that can be difficult to achieve in animation, and that is photorealism. Live action is more convenient, less expensive, and less time consuming. If you have an idea for an animated film that you can easily achieve in real life, then it's going to be easier to create that idea in live action. If you have real human characters, you can achieve great emotion just as well as you can with animation. We, as humans, can easily relate to a real human character we see on screen because we can easily picture ourselves in their shoes. You also have the realistic setting which helps us picture ourselves within their world. We can achieve that in animation nowadays with photorealistic lighting and rendering but there's still that

uncanny valley, and we aren't quite at that point yet where we can achieve complete 100% photorealism in computer graphics. Yet, whenever you do have a crazy, imaginative idea, it might be best to animate it.

B. Animation vs. Live-Action Research Test

A research study done at Texas AM University (2012) talked about the differences between animation and live action. The study involved showing participants a video of students in a classroom cheating on an exam (Figure 2). There were two different versions of that video, an animated version, and a live action version. They tested to see whether the participants noticed anything that would provoke cheating such as eye movements, whispering, moving desks closer, dropping pencils, moving papers closer to the edge of the desk, etc. They ultimately concluded that the participants noticed about the same number of cheating actions in both the animation and live action video letting them know that animation can be a used as an effective resource when showing tutorial videos. They stated that creating an animated video can save time and resources if you're having trouble finding actors, settings, and camera equipment for a live action video. If you're deciding on either using animation or live action to convey better expressions, it really depends on what resources you have. If you have A-List actors available and you have a realistic story set in the real world, it may be better to use live action. Sometimes, animation can be useful for when you have child actors since sometimes children can be difficult to direct in live action. Also, you could easily animate expressions on the child character if the child isn't a great actor.

V. ANIMATION AND THEMATIC ELEMENTS

When looking at thematic elements in narrative storytelling, it's wise to consider the many different types of emotion that encompass that area. Sadness, anger, happiness, and fear are just a few different types of emotion a character goes through throughout their story. If we look at the sadness emotion, we can compare different death scenes in animated and live action films since the theme of death is present in many animated films. Mufasa's death scene in *The Lion King* (2019), while similar in terms of writing, is vastly different than the 1994 version. Simba's facial expressions are more exaggerated in the 1994 version and we can very easily tell what emotion that character is expressing. In the 2019 version, Simba's facial expressions don't tell us much. We know Simba just lost his father, so we expect him to show some form of sadness. This is difficult to do since you're also trying to keep everything as realistic as possible. If we look at another live-action Disney film, *The Jungle Book* (2016), in which there are also photorealistic animals, we see an emotional scene in the middle of the film that feels much more emotional than anything in *The Lion King* (2019). The scene consists of Mowgli saying goodbye to his wolf mother while it's raining heavily. This scene comes off as more emotional than the death scene in *The Lion King* (2019) because of a couple reasons. First, there is a human character. Having a human character in the scene treats the rest of the animals in the movie as actual animals, whereas in *The Lion King* (2019), there are

no human characters, so we associate all the animals in the film as personifications. Because of this, we can't make a distinct connection with the animals or relate to them as actual animals. All the animals are personified and treated as if they were real people. Having no real human character in the film to connect with the animals will fail to connect with the audience, as the audience can't imagine a human/animal relationship existing in the film. In *My Dog Skip* (2000), the ending becomes quite emotional, yet the dog never shows signs of sadness through facial expressions. The dog is treated as a real dog with a human owner. The relationship between the dog and the human feels real and can relate to the audience. The dog doesn't have to show exaggerated facial expressions because the story is set in the real world and real dogs don't have exaggerated facial expressions as seen in animated movies. Another factor that plays heavily into emotional death scenes is music. Whether it's the first 10 minutes of *Up* (2009) or the ending of *Coco* (2017), the music is a key factor in determining how emotional a scene is. Besides the music, the writing, directing, staging, lighting, and all factors used to enhance the thematic elements in a narrative story.

A. Narrative Storytelling

In narrative storytelling, it's important to go through many different emotions before tackling a specific emotion you want to put emphasis on. If you want a character to feel sad, you must show that character happy, angry, scared, or any other type of emotion first so we can relate to them since we, as humans, exhibit many types of emotions. This applies to any medium of storytelling – animation or live action. Narrative storytelling is especially useful for showing heavier themes such as death. As Elinor Ochs (1997) points out: "It is our cares about the present and especially about the future that organize our narrative recollections of past events. Narrative serves the important function of bringing the past into the present time consciousness. That is, narrative provides a sense of continuity of self and society. But perhaps even more importantly, narrative accounts of past events help us manage our uncertain future." Narrative storytelling helps us relate to the world and to understand it better. When showing an emotional scene in a film, it's important to relate to the audience so that they themselves will become emotional. In *The Land Before Time* (1988), all the characters are dinosaurs. They are given stylistic character designs and exaggerated expressions to help convey emotion better. An emotional scene occurs in the beginning of the film where the main character's mother dies in a natural disaster. The music is somber, the setting is dark, and the writing is realistic in how a real mother would talk to a child. Because of this, we can relate to it and understand the story better. It also lets us enjoy the film more because we become interested in the characters and their motives.

B. Using Abstractions to Convey Themes in Animation

Animation can also be used to enhance emotion using abstract visuals. This works especially well in the theme of death because we don't have a clear understanding of death ourselves. *In Watership Down* (1978), there is an emotional death scene that occurs half-way through and the scene uses many abstract elements to convey the theme of death and the relationship between the two rabbit characters. A slow song plays in the background to help further the emotion. The rest of the film is rather violent showing rabbits being shot and chewed up by vicious dogs. The film doesn't shy away from violence as many of the violent scenes contain an excess of blood. Many of the abstract visuals help to convey other emotions such as fear. In the beginning, the main character has a vision of blood swamping over their homeland. This is meant to invoke fear in the audience, another emotion that works well in abstract form. We see many nightmare scenes in horror movies that we can relate to because we ourselves have nightmares and can experience the bizarre events that occur in them.

VI. APPLYING CHILDHOOD NOSTALGIA THEMES TO AN ANIMATED SHORT FILM

Emotional connections between computer-generated characters and the audience are important for narrative storytelling. The animation medium may offer better techniques in character motion so that stronger emotions can be seen from them. A short film that has been in development for about three years now will use what this study has found and apply emotional thematic elements to characters in the story. The theme of childhood nostalgia and coming of age will be shown. The story revolves around a young girl who receives a baby polar bear for her birthday. They grow up together and in the end the girl decides an adult polar bear is too much of a responsibility. She decides to let it go with the final shot showing a stuffed polar bear in the frame letting the audience know it was just a stuffed animal all along. This is a story that will involve lots of character emotion which will be important to convey the themes of childhood nostalgia.

A. Art Style

The film will use a semi-realistic art style with emphasis on saturated colors to convey emotional elements. Like most animated films nowadays, this film will be using a hybrid stylized photorealistic style. This is also to help learn the basics of animation production that are used by most studios today. The characters will include a young girl, a baby polar bear, an older girl, and an older polar bear. The characters themselves will be slightly more stylized with bigger eyes and more exaggerated proportions like characters in most animated films today. Environments will be realistic but at the same time, still look stylized. No voice acting will be used as more emphasis on the facial emotions of the characters to convey emotions.

B. Thematic Elements

The thematic elements used in this film will revolve around childhood nostalgia and coming of age. The young girl will grow older with the polar bear, but as she grows older, she will realize that taking care of a full-grown adult polar bear is too much of a responsibility and unrealistic. Having the animal be something exotic will help convey this theme since taking care of an exotic animal, in reality, is quite dangerous. Having the polar bear be a stuffed animal in the end will convey the theme of childhood and growing up. Since children are usually attached to their stuffed animals while

they are young and drift away from them as they grow older, having the theme revolve around a stuffed animal will fit well with the theme of childhood and coming of age.

VII. CONCLUSION

Using the animation medium to help tell narrative stories can help enhance the theme of childhood and coming of age. Themes are an important part of storytelling and having a good sense of emotion within the characters can help convey these thematic elements. We see lots of animated films with emotion and even though what we're seeing isn't real, we can still relate to it. Whether it's a talking rabbit or a bouncing lamp, we're able to connect to those characters and imagine ourselves in their shoes using exaggeration, movement, and other principals of animation. This helps us better understand ourselves and the world around us making it a true, sincere artform.

REFERENCES

[1] Anolli, L., Vescovo, A., Agliati, A., Mantovani, F., & Zurloni, V. (2006). Simulation-based training of communication and emotional competence for the improvement of physician-patient relationship. *Annual Review Of Cyber Therapy And Telemedicine, 4*, 80-87. https://issuu.com/bepperiva/docs/arctt_2006

[2] Beck, A. (2011). *Perception of Emotional Body Language Displayed by Animated Characters*. [Unpublished doctoral dissertation]. University of Portsmouth. https://core.ac.uk/download/pdf/40013046.pdf

[3] Bernier, Matthew, and Judith O'Hare. (2005). *Puppetry in Education and Therapy: Unlocking Doors to the Mind and Heart*. AuthorHouse.

[4] De Melo, C., & Paiva, A. (2007). Expression of Emotions in Virtual Humans Using Lights, Shadows, Composition and Filters. *Affective Computing and Intelligent Interaction, 2007*, 546-557. https://link.springer.com/chapter/10.1007/978-3-540-74889-2_48

[5] Ekman, P. (1999). Basic Emotions. In T. Dalgleish and M. Power (Eds.), *Handbook of Cognition and Emotion* (pp. 45-60). John Wiley & Sons. https://www.paulekman.com/wpcontent/uploads/2013/07/Basic-Emotions.pdf

[6] Harter, Lynn M. (2008). *Narratives, Health, and Healing: Communication Theory, Research, and Practice*. Routledge.

[7] Lee JM, Baek J and Ju DY (2018) Anthropomorphic Design: Emotional Perception for Deformable Object. *Front. Psychol. 9(1829)*. https://doi.org/10.3389/fpsyg.2018.01829

[8] McDonnell, R., Breidty, M., & Bülthoff, H. H. (2012). Render me real? Investigating the effect of render style on the perception of animated virtual humans. *ACM Transactions on Graphics, 31*(4), 1–11. https://dl.acm.org/doi/10.1145/2185520.2185587

[9] Oberfeld, D., Wilms, L. (2015). *Effects of color on emotion: Evidence from self-report ratings and physiological measures*. Conference of the International Society for Research on Emotion, Geneva, Switzerland. https://www.researchgate.net/publication/28335667_Effects_of_color_on_emotion_Evidence_from_self-report_ratings_and_physiological_measures

[10] Ochs, E. (1997*). Narrative, Discourse as structure and process: Discourse studies: A multidisciplinary introduction*, (Vol. 1., pp. 185–207). SAGE Publications Ltd. https://doi.org/10.4135/9781446221884.n7

[11] Pardew, Les. (2008). *Character Emotion in 2D and 3D Animation*. Thomson Course Technology.

[12] Pereira A., Leite I., Mascarenhas S., Martinho C., Paiva A. (2011) Using Empathy to Improve Human-Robot Relationships. In Lamers M.H., Verbeek F.J. (eds*), Human-Robot Personal Relationships* (pp. 130-138). HRPR 2010. Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering, vol 59. https://doi.org/10.1007/978-3-642-19385-9_17

[13] Smith, D., McLaughlin, T. & Brown, I. (2012). 3-D Computer Animation vs. Live-Action Video: Differences in Viewers' Response to Instructional Vignettes. *Contemporary Issues in Technology and Teacher Education*, 12(1), 41-54. https://www.learntechlib.org/primary/p/37618/

[14] Wisessing, P., Dingliana, J., & McDonnell, R. (2016). Perception of lighting and shading for animated virtual characters. *Proceedings of the ACM Symposium on Applied Perception, 16*, 25–29. https://www.scss.tcd.ie/Rachel.McDonnell/papers/SAP2016b.pdf