Humor in neurodevelopmental conditions

Cognitive competencies, individual differences, and expressivity in relation to humor in individuals with autism spectrum disorder and Williams syndrome

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« L'humour c'est ce qui évite à la lucidité de sombrer dans l'amertume »

(Lacroix, 2006).

À Marius et Alice,

À Joachim, Arthur, Adam, Zacchari, Olivia, Manech et Orjan,

Je vous dédie cette thèse, en espérant que vous grandirez en continuant de voir le monde comme autant de bonnes raisons de vous (en) amuser.

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Abstract

Humor is an important component of human communication that enhances the quality of social interactions and fosters social bonding. Moreover, humor can enrich psychological well-being, notably through its role in emotion regulation. Indeed, humor can help people to deal with their negative emotions, either through distraction, by occupying their mind with a humorous thought, or through helping them to reinterpret a given situation differently. However, humor also presents with a darker side. When it is intentionally hurtful, it can have strong negative consequences on the well-being of victims of mockery. Similar consequences can result if humor is wrongly perceived. It is thus important to better understand humor processing in individuals with different conditions, who might develop specific positive or negative relationships with humor. The goal of this cumulative thesis was, therefore, to contribute to ongoing research regarding the understanding of humor processing in individuals with neurodevelopmental conditions, specifically autism spectrum disorder (ASD) and Williams syndrome (WS), two conditions that appear to be at two extreme poles of the social motivation spectrum. Moreover, this thesis takes on a transdiagnostic perspective, to read individual differences regarding humor processing and appreciation beyond specific developmental condition classifications.

This thesis is situated around three main components of humor: cognitive competencies, individual characteristics, and behavioral responses. These components are explained and developed in the introductory chapter (Chapter 1: Introduction). First, the cognitive foundations of humor are briefly presented, with a particular focus on incongruity-resolution theories of humor. It is argued and demonstrated that humor is a complex cognitive task to process, much more than it might initially appear. Second, this chapter addresses how humor can be differentially perceived according to the individual characteristics that influence the development of specific humor styles, how humor is appreciated, and the general temperament of people toward humoristic interactions. The third part of this introductory chapter describes the behavioral responses that are commonly related to the appreciation of humor, namely smiles and laughter. To convey the conceptual foundations of the concept of humor as it is approached in this thesis, a section on the functions of humor highlights why the study of humor in neurodevelopmental conditions is necessary and important. Next, since this thesis focuses on ASD and WS, these conditions are briefly described and presented. So too is Down syndrome (DS), a third group of investigation. This

chapter also clarifies why and how ASD and WS appear as two extremes of a social motivation spectrum and addresses what research has already brought to the knowledge base on humor in these two conditions. Finally, the Introduction chapter closes with a discussion of the goals and methodological context of this thesis.

This cumulative thesis is based on four articles: Articles 1 to 4. The discussion of these is presented in Chapter 2: Articles. Article 1 presents a conceptual overview of the research and knowledge base on humor processing in individuals with ASD and WS, and suggests several lines of thought for future research. Article 2 presents the results of a survey-based study on gelotophobia (i.e., the fear of being laughed at), which was distributed to the parents of young individuals (5–25 years of age) with ASD (N = 48), WS (N = 43), and DS (N = 139). The results confirmed that autistic individuals are particularly prone to developing gelotophobia and this tendency is in line with their high-level seriousness and bad mood. These results also suggest to understand these individual differences from a transdiagnostic perspective. Article 3 presents the results of a second survey-based study that investigated different humor styles; this was distributed to the parents of young verbal individuals (5–25 years old) with ASD (N = 31), WS (N = 34), and DS (N = 82). The results showed that autistic individuals seem to engage more in self-defeating humor and from a transdiagnostic perspective, this is linked to their tendency to develop conduct problems. Finally, Article 4 presents an experimental study that investigated expressive responses to humorous and non-humorous stimuli, and a general understanding of simple types of humor, in individuals with WS (N = 8) and typically developing (TD) children (N = 9). The results revealed that individuals with WS are able to understand and appreciate simple humor in much the same way as TD children, but they tend to express more “extreme” responses in the sense that they more easily engage in laughing out loud.

The final chapter of this thesis (Chapter 3: General discussion and conclusion) presents a general overview and discussion of the main findings of all four articles and examines what they bring to the ongoing knowledge base on humor in general as well as in neurodevelopmental conditions. This chapter also resumes the strength and importance of interpreting the survey-based findings presented in Articles 2 and 3 from a transdiagnostic perspective and offers several practical implications and suggestions for future research. This final chapter also presents the main limitations and strengths of the research presented in this thesis and closes with some concluding remarks. Overall, this thesis refines our understanding and raises awareness of individual differences in relation to humor processing.

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1 Introduction

> "Humor may or may not add years to your life, but it will certainly add life to your years." (McGhee, 2010, p. 24)

Since I began studying humor, it has become more and more obvious to me that it holds an important place in our everyday lives. I would like to challenge the reader to a little mental exercise: try to be attentive to your everyday interactions and activities and find one day without encountering at least one form of humor. When I did this exercise myself, I realized how important humor was in our lives for two main reasons: it helps us bond with others (what is better than a good laugh to help us feel close to someone else?) and face the challenges of life (I do not know how I would have been able to sleep without a good episode of *The Office* to calm me down and cheer up my doctoral student's brain). Humor brings color to the darkest sides of life, funniness to the absurdities, and lightness to our daily burden. It makes people beautiful and can operate as a fantastic icebreaker. In short, humor can make our lives lighter and brighter. It is omnipresent in human communication and plays a significant role in regulating negative emotions and enhancing positive ones, and fostering social interactions. Through these functions, humor can enhance individuals' psychological well-being, as long as it is understood and appreciated.

However, humor is more complex than one originally imagines. First, humor is not only a beautiful shield against sadness and meaninglessness, it can also be a hurtful sword when it is used to mock, threaten, or depreciate another person. When a joke is not understood or when humor is used in an intentionally mean way, humor can hurt and darken human life. Thus, it has both a dark and a light side, and the power of one over the other depends greatly on an individual's characteristics, cognitive abilities, and temperament. Second, humor is a highly complex cognitive task to process. Indeed, it relies on the ability to shift from an initial perception—that could, by itself, appear as nonsense, a lie, or a mistake—to a correct interpretation of humorous content. As such, it requires relatively high cognitive skills, such as cognitive flexibility (the ability to switch from one perception to the other), as well as important social skills, such as the ability to understand others' humorous intentions. Given this, it is easy to imagine that individuals with neurodevelopmental conditions, who can present with difficulties in social communication, emotion regulation, or specific types of cognitive processing, might deal with humor differently. For example,

individuals with intellectual disabilities might have more difficulty understanding complex forms of humor. Those with cognitive flexibility difficulties will also find it harder to understand and thus appreciate different types of humor. Fruitful research has been conducted on humor processing in autistic individuals, who have been reported as typically having difficulties in understanding some types of humor. Moreover, autistic individuals seem to have lowered social motivation compared to typically developing (TD) individuals, which also renders them intrinsically less motivated to engage in humorous interactions. Thus, autistic individuals might have difficulties with some types of humor, but this does not mean that they do not appreciate humor; they might have their own specific sense of humor. Interestingly, individuals with Williams syndrome show a very different socio-emotional profile, as they are generally described as cheerful, smiling, and outgoing. However, they also present with a cognitive profile that might impact their ability to understand complex types of humor.

Considering the important role of humor in communication and its positive and negative impacts on well-being, it is crucial to develop the knowledge base about humor in neurodevelopmental conditions. Indeed, it is important to better understand how individuals with specific neurodevelopmental conditions interact with the world. Moreover, understanding their relation to humor is the first step in supporting them to use humor as a tool for regulating their emotions and fostering their social interactions. Thus, the goal of this thesis is to investigate humor comprehension, appreciation, and behavioral expression in individuals with different neurodevelopmental conditions such as autism spectrum disorder (ASD) and Williams syndrome (WS), but also from a transdiagnostic perspective, as laid out further below. ASD is a highly heterogeneous neurodevelopmental condition that is mainly characterized by difficulties in social communication, restrictive interests and repetitive behaviors (American Psychiatric Association [APA], 2022). In terms of their typically developing peers, individuals with ASD have also been described as experiencing negative emotions more frequently, as being particularly serious (Samson et al., 2012) and as being less motivated to interact with others (Chevallier et al., 2012a). WS is a rare genetic condition that involves intellectual disabilities and other several psychological and physical characteristics (Morris & Mervis, 2021). Individuals with WS are notably described as being hypersociable, seeking social interaction, and particularly cheerful (Järvinen et al., 2013). In that way, these two conditions appear to have almost opposite socio-emotional profiles, notably in terms of their social motivation, i.e., they eagerness to interact with others.

This thesis begins with an introductory chapter, which introduces relevant theoretical concepts about humor research. It is articulated around three main areas of research that constitute components of humor: (1) the cognitive foundations of humor, including the semantic and cognitive basis of humorous content, to highlight which cognitive resources support our understanding of humor, (2) the individual characteristics that can influence one's attitude towards humor, including the specifics of what is commonly known as "a sense of humor", and (3) the behavioral responses to humor, typically smiling and laughing. Together, these sections lead into a discussion of the functions of humor for social interaction and well-being, to understand why studying humor is not just fun, but is also important. Then, I briefly describe the two neurodevelopmental conditions that are the focus of this thesis: ASD and WS. I also explain why, aside from better understanding ASD and WS in themselves, investigating humor in these two conditions makes sense and can be informative, since they share similarities but also present important differences. Finally, the last section of this introduction chapter presents the specific goals of this thesis and some methodological considerations, and provides an overview of the four papers that form the basis of the work.

The second chapter of this thesis presents four articles: one conceptual paper on humor in autism and WS in the cognitive, social, and emotional domains; this is effectively a second and shorter introduction aimed at shedding light on the importance of the research presented in this thesis. The second article is a survey-based article that addresses gelotophobia, i.e., the fear of being laughed at, in neurodevelopmental conditions. The third article, which is also survey-based, presents an analysis of the use of different humor styles in individuals with neurodevelopmental conditions. Finally, the fourth article presents an experimental study that examines how individuals with WS compared to typically developing (TD) children understand simple humorous stimuli and their behavioral responses related to them (i.e., smiles and laughs).

Finally, the last chapter of this thesis addresses how this thesis contributes to the knowledge on humor in general and in neurodevelopmental conditions. It also considers the limitations of this thesis, perspectives for future research, and the practical impacts of developing a wider knowledge of humor in neurodevelopmental conditions.

1.1 Cognitive foundations of humor

1.1.1 Incongruity-resolution theories

Currently, the most widely used theories on the cognitive processes of humor are incongruity-resolution theories, which state that incongruity lies at the basis of any humor; that is, there is a mismatch between what is expected and the actual outcome (i.e., the punchline). For the incongruity to become humorous, we not only have to detect the incongruity, we also have to resolve it, at least partially, in order to make sense of it and understand its humorous purpose. Incongruity-resolution involves finding a cognitive rule that resolves the incongruity and allows us to make the link between the initially mismatched propositions (Suls, 1972). While Suls (1972) initially proposed two stages to resolve an incongruity (detection and then resolution), Ruch (2008) included a third step, which involves "detecting that what makes sense is actually nonsense. This third stage then allows distinguishing between joke processing and mere problem solving" (Ruch, 2008, p. 27). Take the following example: "You can tune a guitar, but you can't tuna fish. Unless, of course, you play bass" (Adams, n.d.)[1]

First, one would have to detect the incongruity: it is not possible to "tune" a fish, and there seems to be a spelling mistake ("tuna fish" or "tune a fish"). Plus, it does not make sense for anyone, not even a bass player, to tune a fish. This, by itself, does not make the text humorous content but merely a conceptual (tune a fish) or spelling (tuna fish) mistake. To make it humorous, one has to find the cognitive rule that links the incongruity with a humorous intention. Thus, one has to detect and understand that "tuna fish" is a pun for "tune a fish," which is emphasized by the second part of the joke, where "bass" is also a pun since it is both an instrument and a type of fish. Therefore, to make sense of these incongruities, one has to take a step back and understand the puns between statements a music instruments and two types of fish, namely tuna and bass.

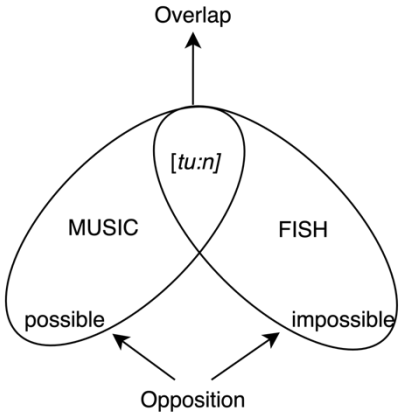
Suls' (1972) model presents the cognitive process of understanding humorous content, from a psychological point of view. However, linguists have rather focused on

[1] The joke is always reported as being from Douglas Adams, an English author, screenwriter, and humorist (he notably wrote The Hitchhiker's Guide to the Galaxy). However, the specificities (place and year) of the source are unknown.

describing the *joke* itself and what makes it funny, which allows a more refined understanding of the cognitive origins of humor. The most well-known cognitive linguistic theories on the foundations of verbal humor are based on the concept of *script opposition*. Raskin (1985) presented the semantic script theory of humor (SSTH), describing jokes as relying on two (or more) scripts,[2] (i.e., semantic structures that evoke images, situations, contexts, etc.) that (a) *overlap* (two meanings/interpretations exist at the same time), and (b) are *opposed*. The scripts can be opposed on different bases, such as possible/impossible, real/unreal, normal/abnormal, good/bad, life/death, etc. Taking the first sentence of the joke by Adams (n.d.) given above, there are two scripts, namely the script MUSIC and the script FISH. Both scripts overlap and make sense on their own, but they are opposed to each other (i.e., they do not make sense together) on the basis of a possible/impossible opposition (see Figure 1 for a graphical representation).

Figure 1

Visual representation of the joke "You can tune a guitar, but you can't tuna fish"



Note: Based on the visual of script opposition and overlap in Attardo et al. (2002, p. 26). The two scripts MUSIC ("tune a") and FISH (tuna) overlap on the phonetic sound [tuːn] (US) or [tʃuːn] (UK) but are opposed on that the MUSIC script is possible, whereas the FISH script is impossible.

In 1991, an extension of the SSTH, the general theory of verbal humor (GTVH), was presented by Attardo and Raskin (1991). The GTVH presents a list of six parameters (i.e., knowledge resources) that constitute the funniness of verbal humor and notably allow for its

[2] "Scripts are, therefore, formal semantic entities, resulting from an established procedure of semantic analysis of a text and its linguistic context."(Raskin, 1987, p. 16).

analysis and categorization. First, the notion of *script opposition* (SO) remains as the central requirement, as in the SSTH. Second, the authors added *logical mechanisms* (LM) to understand the basis of (verbal) humor; these describe how an incongruity should be resolved on the basis of specific cognitive rules.[3] The authors described 27 logical mechanisms, such as role reversal, analogy, proportion, parallelism, etc. There are four other knowledge resources: The *situation* (SI), which can be seen as the "props" of the joke and relates to everything that is evoked (objects, activities, etc.); the *target* (TA), which defines the victim or the butt of a joke; the *narrative strategy* (NS), which considers the narrative form of the joke (dialogue, question answer, proverb, riddle, etc.); and finally, the *language* (LA), which defines the phonological, syntactic and lexical basis of the joke (choice of words, place of words in the sentence, etc.). Of particular interest for the study of humor in neurodevelopmental conditions is the concept of logical mechanisms, which points out that different types of humor require different cognitive rules to understand them, i.e., to solve the incongruity. As such, some types of humor are more cognitively demanding than others, and each type involves specific cognitive capacities. Samson et al. (2008) examined the neural correlates of cognitive humor processing involved in different kinds of cartoons that differed in their logical mechanisms: visual puns (based on visual resemblance, where one visual element evokes two different meanings), theory of mind cartoons (requiring social perspective-taking skills, since participants need to be able to recognize that one character in the joke is in a state of false belief), and semantic cartoons (based on semantic relationships that do not involve visual puns or theory of mind). The results showed that these different types of cartoons involved different networks in the brain, confirming that each type of humor requires specific cognitive abilities. As such, it seems logical to conclude that individual differences regarding specific cognitive processes, such as mind-reading abilities or the understanding of non-literal verbal utterances, will impact people's understanding and appreciation of specific types of humor.

The reader might have noticed that the study presented above (Samson et al., 2008) used *cartoons* as stimuli, whereas the incongruity-resolution theories presented earlier

[3] In the example "You can tune a guitar, but you can't tuna fish", the implied logical mechanism is called "cratylism," or "cratylistic syllogism" (Hempelmann, 2004). Basically, it involves the reader hearing the phonetic sound [tuːn] (US), or [tʃuːn] (UK), to understand it can correspond to two interpretative propositions, which resemble each other in terms of sonority but not in terms of meaning.

describe verbal humor. Humor can be seen as a sort of "umbrella term," since it combines different forms; it can be verbal (e.g., jokes), visual (e.g., cartoons), acoustical (e.g., funny sounds), or behavioral (e.g., pretending to fall) (Ruch, 2008). Moreover, humor has a great spectrum of complexity, ranging from simple (e.g., funny faces) to complex forms (e.g., irony). It has been noticed that incongruity theories originally described the structure of (short) *jokes*, which is only one (and arguably the simplest) type of humor (Attardo, 2008). Some aspects of these theories can, however, be extended to other types of humor, notably visual humor. For example, cartoons have been defined as a "humor-carrying visual/visual-verbal picture, containing at least one incongruity that is playfully resolvable in order to understand their punchline" (Hempelmann & Samson, 2008, p. 614). Moreover, it has been acknowledged that logical mechanisms are also applicable to visual humor (e.g., juxtapositions, exaggerations, part/whole substitution, parody, etc.) (Hempelmann & Samson, 2008). There are inevitably important differences between visual and verbal humor, but it appears. that the basis of any type of humor seems to be an incongruity-resolution process.

There is one type of humor, however, that does not follow the above-described steps of the incongruity-resolution process: nonsense (or absurd) humor, which specifically relies on the principle that the incongruity is not resolvable. The foundation of nonsense humor is also incongruity, but this incongruity is either (1) unresolvable, (2) partially resolvable, or (3) the source of new incongruities or absurdities (McGhee et al., 1990). The resolution information in nonsense humor gives the impression that it is possible to make sense out of an incongruity, although it does not actually make sense: "The recipient's ability to make sense or to solve problems is exploited; after detecting the incongruity he is misled to resolve it, only to later discover that what made sense for a moment is not really making sense." (Ruch, 2001, pp. 21–22).

Nonsense (or absurd) humor thus does not proceed through the three steps of the incongruity-resolution process, and research has even shown that it does not involve the same neural mechanism as humor based on incongruity-resolution (Dai et al., 2017; Samson et al., 2009).

In sum, humor is manifold and based on cognitive tasks much more complex than one might expect. Indeed, it relies on the ability to (1) detect an incongruity, meaning that one has to have knowledge of what would normally happen, (2) find the right cognitive rule to switch from detecting an incongruity to actually making sense (or not) out of it, which requires

high cognitive flexibility (Ozonoff & Miller, 1996), and (3) understand the humorous intentions behind the intended mistake (Ruch, 2008), which requires important social communication competencies. The cognitive factors involved in humor processing depend on the type of humor involved. Typically, working memory seems related to process verbal and nonverbal humor, whereas verbal humor relies specifically on verbal abstraction and nonverbal humor on visual attention (Shammi & Stuss, 1999). However, the cognitive factors involved in humor comprehension seem unclear and results differ in the literature. Whereas some researchers suggest a predictive role of cognitive flexibility, response inhibition, working memory, verbal or visual reasoning, and concept formation for verbal and nonverbal humor processing (Bihrle et al., 1986; Dagge & Hartje, 1985; Ruch et al., 1990; Shammi & Stuss, n.d., 1999), Baldwin (2007) has revealed no such predictive relation. The contribution of theory of mind in humor processing has also been a subject of debate. Whereas some authors have suggested it was a necessary ability to process humor (Howe, 2002), more recent research has rather suggested that humor is a component of broader pragmatic skills and that theory of mind seems necessary only to process certain types of jokes, namely those it is necessary to process only certain types of humor, namely those that require reasoning about a character's mental state to be understood (Bischetti et al., 2023; Samson, 2012). The complexity of humor is a given, although it depends on the type of humor involved. Some types of humor are simpler than others to process, and thus the understanding and production of different types of humor occur at different stages in human development; although, basic humor processing starts to develop shortly after birth in typically developing individuals, as the next section briefly describes.

Studying humor in neurodevelopmental conditions thus requires being aware of and specific about the type of humor that is under investigation, to shed light on which cognitive abilities might be impaired or strengthened in different conditions.

1.1.2 Development of humor

Infants are already able to detect (non-humorous) incongruities at 3.5 months old, which has notably been demonstrated in a series of studies showing the ability to detect when an object challenges the laws of physics (Baillargeon, 1998). As such, the cognitive abilities required for the first step of the incongruity-resolution process, which is "detecting an incongruity," begin to develop shortly after birth. The understanding of simple basic

humor, based on absurd and incongruous behavior such as funny faces or sounds, has also been shown as emerging early in human development. Mireault et al. (2015) demonstrated that infants as young as 5 months old laugh at simple humorous events (i.e., absurd behavior from an experimenter) independently of their parent's reactions. Infants also start producing simple humor, better known as "clowning," already at 3–6 months of age (Mireault et al., 2012).

This ability to solve the incongruity in humorous content seems to be related to the understanding of the joker's intentionality (Mireault, 2022). Indeed, the ability to understand humor lies in the ability to understand that others can *intentionally* do the wrong thing, which allows us to identify the difference between a mistake and an intentional falsehood, such as pretense acts, lies, or jokes (Hoicka & Gattis, 2008; Hoicka & Martin, 2016). Two-years old children are able to understand the intentionality behind pretense acts (Rakoczy & Tomasello, 2006), and 3-year-olds can understand the difference between a mistake and a lie (Siegal & Peterson, 1998). Joking is a form of doing the wrong thing that "requires children to know that (1) what has been said or done is wrong, (2) the joker intended to say or do the wrong thing, and (3) the joker intended for the listener to disbelieve the falsehood" (Hoicka & Gattis, 2008, p. 181). To test toddlers' ability to detect this intention, Hoicka and Gattis (2008) ran an experiment in which they interacted with objects in the wrong way, either with a humorous intention showed by laughter and positive facial expression, or without such an intention, by saying "whoops!" and having a negative facial expression. The children were then given the objects and asked to interact with them; if they understood the experimenter's intentions, they *corrected* the mistake and *copied* the humorous action. The results therefore showed that 2- to 3-year-old toddlers were able to identify the difference between a mistake and a joke by inferring the experimenter's intention and rightly correct or copy the action.

Thus, the literature has shown that the production and understanding of humor appear early in children's development when it comes to simple types of humor. The studies cited above focused on clowning and simple funny behaviors. However, the understanding and production of complex types of humor develop later in the lifespan. For example, an understanding of irony develops only around primary school age (Mazzarella & Pouscoulous, 2021; Pouscoulous, 2013). The emergence of different types of humor relies on their form and complexity, and indisputably, humor presents with a wide range of complexities and

specificities. As such, the study of humor has to acknowledge these different shades of humor and be specific about which type is being investigated.

1.2 Individual characteristics

1.1.2 Humor styles

Humor does not only involve different forms and levels of cognitive difficulty; it also varies according to whether it is well-intentioned or ill-intentioned, and whether it is directed towards oneself or another person. These variabilities lead to different humor styles, for which different categorizations have been proposed. For example, the first categorization to emerge was the Humorous Behavior Q-Sort Deck (HBQD; Craik et al., 1996), which distinguishes between 10 styles of everyday humorous conduct, based on five bipolar factors: socially warm vs cold, reflective vs boorish, competent vs inept, earthy vs repressed, and benign vs mean-spirited. To my knowledge, the most recent categorization is the Comic Style Markers (CSM, Ruch et al., 2018), which introduced eight comic styles: fun, humor, nonsense, wit, irony, satire, sarcasm, and cynicism. However, the categorization by Martin et al. (2003) has probably been the most widely used in the literature to define individual differences in the use of humor in everyday life.

Martin et al. (2003) developed a 2 x 2 (target x valence) conceptualization of the functions of humor, which resulted in the highlighting of four different humor styles in the everyday production of humor. The first distinction concerns the *target* of the humorous content. As such, humor production can exercise an *intrapersonal*[4] function (when the target is oneself) to enhance and protect the self, cope with stress, relieve tension, or use humor as a defense mechanism. It can also serve an *interpersonal* function (when the target is another person) to enhance relationships with other people by increasing their feelings of well-being, reducing conflict, increasing one's attractiveness, enhancing group cohesiveness, reinforcing group norms, etc. (Martin et al., 2003). The second distinction is about the *valence* of the humorous content; thus, humor can either be *positive* (benign and tolerant) or *negative*

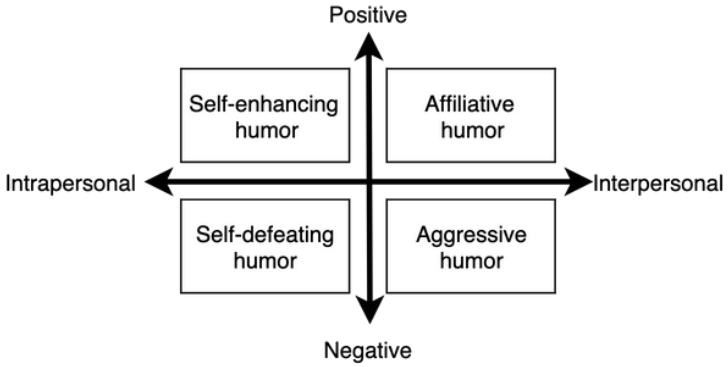
[4] Martin et al. (2003) use the formulation "intrapsychic," which is adapted in this manuscript to facilitate the readiness of the opposition between inter- and intra-personal.

(hostile and injurious) towards either the self or others. The valence of humorous content, however, depends greatly on the context. Martin et al. (2003) specify that the distinction between benign and hostile humor is a matter of degree rather than a proper dichotomy. Indeed, slight teasing (typically categorized as negative humor towards others) can be a positive way to build a relationship with someone if that person is not hurt by the humorous act; thus, it would count as a positive type of humor. On the other hand, self-deprecation (typically characterized as negative humor towards oneself) can become negative when it is used excessively or too frequently, but at a low level, it can be positive and adaptive. Thus, the valence of humorous content is really a matter of intensity and self-perception, rather than being a fixed objective and measurable border.

Based on the target and valence distinctions of humorous content, Martin et al. (2003) proposed a model with four humor styles, which relate to individual differences in humor use (Figure 2).

Figure 2

Model of the four humor styles based on a 2 x 2 categorization (target x valence)



Note: Categorization based on Martin et al.'s. (2003) definition of humor styles. Design based on Besser and Zeigler-Hill (2011); adapted by the author.

Affiliative humor occurs when humor is produced to enhance one's relationship with others in a benevolent and benign way. This type of humor is directed towards others in a positive way (i.e., with the goal of facilitating relationships and reducing tensions), as it is

harmless, non-hostile, and tolerant. *Aggressive humor* occurs when humor is produced at the detriment of others, who might feel hurt or alienated. It includes sarcasm, ridicule, or derision, as well as humor used to manipulate others by implying the threat of ridicule. *Self-enhancing humor* concerns humor that is produced to enhance one's well-being in an attempt to cope with stress and regulate one's own emotions. Individuals who are high on this dimension tend to generally look at life, and its incongruities and adversities, with an amused and humorous eye. Finally, *self-defeating humor* is about producing negative and harmful humorous content directed against oneself. It involves self-disparaging humor; that is, trying to integrate or gain approval by letting others mock and ridicule oneself. It also includes a tendency to avoid and deny the existence of problems by engaging in humorous behavior to hide negative feelings (which is different from positive humorous "coping" behavior, since here, it is a matter of denial and not reappraisal).

To assess individual differences in humor styles, Martin et al. (2003) developed the Humor Style Questionnaire (HSQ), which assesses an individual's tendency towards specific humor styles, based on a 32-item (eight items per style) questionnaire. In addition to testing the reliability of the HSQ in a population of TD adults, the authors also assessed how different humor styles correlate with personality traits. Amongst others, they tested the associations between humor temperament, namely cheerfulness, seriousness, and bad mood (State and Trait Cheerfulness Inventory; Ruch et al., 1996), personality traits based on the Big Five model, which are conscientiousness, openness, agreeableness, neuroticism, and extraversion (Revised NEO Personality Inventory; Costa & McCrae, 1992), psychological well-being (Ryff, 1989), depression (Center for Epidemiological Studies Depression Scale; Radloff, 1977), hostility (Symptom Checklist-9; Derogatis, 1977), anxiety (State and Trait Anxiety Inventory; Spielberger et al., 1969), self-esteem (Index of Self-esteem; Hudson, 1982; Rosenberg Self-Esteem Inventory; Rosenberg, 1965), and optimism (Life Orientation Test; Scheier & Carver, 1985). Table 1 presents the main associations between the different humor styles and these personality traits (Martin et al., 2003).

The development of the HSQ marked an important turning point in humor research. Indeed, it allowed researchers to take into account differences in the type of valence of humor, to better determine individual tendencies to engage in positive (adaptive) or negative (maladaptive) humor styles. For the study of humor in neurodevelopmental conditions, determining whether individuals engage in these different styles of humor can help

researchers understand the specificities of different conditions. The individual characteristics associated with humor styles underlined by Martin et al. (2003) are not the only individual differences related to humor that researchers have noted and studied in the literature over the years. Indeed, a variety of individual differences, such as gender, age, cultural belonging, or cognitive abilities, to give just a few examples, can influence an individual's relationship with humor (Ruch, 2008). Research on these characteristics and their relationship with humor have allowed to refine the understanding of humor.

Table 1

Associations between humor styles and personality traits (Martin et al., 2003)

	Positive correlation	**Negative correlation**
Affiliative	cheerfulness, extraversion, openness to experience, self-esteem, psychological well-being	seriousness, bad mood, anxiety, depression
Aggressive	neuroticism, hostility, aggression	agreeableness, conscientiousness, seriousness
Self-enhancing	cheerfulness, optimism, self-esteem, well-being, openness, extraversion	mood, depression, anxiety, and neuroticism
Self-defeating	bad mood, depression, anxiety, neuroticism, hostility, aggression	psychological well-being, self-esteem, agreeableness, conscientiousness

Note: Based on Martin et al. (2003); adapted into a table by the author.

1.2.2 Humor temperament

One important element that explains individual differences regarding humor is humor temperament, i.e., the general tendency of individuals to be in a state of mind that makes them more or less open to humor.

> "There is both *interindividual* (i.e., between individuals) and *intraindividual* (i.e., across situations) variation in humor behavior. Some people tend habitually to appreciate, initiate, or laugh at humor more often, or more intensively, than others do. In everyday language this enduring disposition typically is ascribed to the possession of a "sense of humor" and various type nouns (e.g., cynic, wit, wag) and trait-describing adjectives (e.g., humorous, witty, cynical) exist to describe individuals extreme in one form or the other. Aside of interindividual differences with a relative stability over time there are also actual dispositions for humor which do vary over time. We are all inclined to appreciate, initiate, or laugh at humor more at given times and less at others. In everyday language phrases like to be in good humor, in the mood for laughing, out of humor, ill-humored, in a serious

> mood or frame of mind etc. refer to such states of enhanced or lowered readiness to respond to humor or act humorously." (Ruch & Köhler, 2007, p. 203)

As described in the above quotation, these different "senses of humor" seem to partially evoke different humor styles, but they also depend on an individual's dispositions and temperament towards positive emotions, laugher, smiling, and more specifically, humor itself. Ruch et al. (1996) identified three concepts that constitute the basis of one's openness to humor: cheerfulness, seriousness, and bad mood. These can appear as dispositions or temperament: the former are otherwise known as *states* (momentary manifestation); the second, which is of greater interest to the present study, is characterized by *traits* (habitual tendency). Cheerfulness as a trait can be described as a personality trait that characterizes a person who is open to humor, smiles and laughs easily, and generally looks on the bright side of life. It correlates negatively with the two other traits—seriousness and bad mood—that are related to humorlessness. Seriousness is the trait that makes individuals see life in a more serious manner, be more organized and analytic rather than spontaneous, favor soberness over funniness, and consider everyday happenings thoroughly rather than superficially (Ruch & Köhler, 2007). Bad mood as a trait is related to a tendency towards feeling sad and grumpy and engaging in ill-humored behaviors, even in situations that supposedly evoke cheerfulness (Ruch & Köhler, 2007). The difference between these two humorless traits is that seriousness relates more to a cognitive way of approaching and appraising life's events, whereas bad mood refers to an affective state. In sum, individuals high on cheerfulness tend to be easily amused, whereas individuals who are high on seriousness and bad mood will be less inclined to appreciate humor. The temperamental bases of humor can be measured using the State and Trait Cheerfulness Inventory (STCI; Ruch et al., 1996). The trait subscale of the inventory consists of 30 items that measure an individual's tendency to be cheerful, serious or in a bad mood. This scale has been shown as being a reliable tool for measuring individual differences in humorous temperament (Carretero-Dios et al., 2011; Ruch et al., 1996) and has been widely used in humor research.

Individuals differ in their appraisal and appreciation of humor relative to their general cognitive competencies and individual characteristics, such as their preferences for specific humor styles, and their tendency to demonstrate either a humorful or a humorless temperament. Moreover, individuals also differ in their behavioral response to humor. Indeed, in response to a positive evaluation of humorous content, some individuals will more easily

smile and laugh than others. The next section describes the main positive behavioral responses to humor: smiling and laughing.

1.3 Behavioral response to humor

When humor is appreciated and leads to positive emotions, the commonly described positive behavioral responses to humor are smiling and laughter. However, not all smiles and laughs are related to humor.

1.3.1 Smiling

There are around 20 types of smiles (Ruch, 2008) that are not necessarily related to amusement, funniness, or mirth. Indeed, smiling can typically be used to mask negative emotions: we all know how to smile and respond “I’m fine” when we actually feel like the earth is collapsing beneath our feet. A smile can also accompany other emotions that are not necessarily positive but can typically be mixed emotions, such as the enjoyment of a fearful situation. Smiling can also take a variety of socially significant roles: the flirting smile, the sadistic smile, the embarrassed smile, or the contemptuous smile, are a few examples (Ruch, 2008). The variety of different smiles do not all look the same and involve different facial muscles that get activated to various degrees. Of the different combinations of muscle activities, only one is considered to be a genuine smile related to amusement; Ekman et al. (1990) called this the *Duchenne smile*. It triggers the activation of the *zygomatic major* (the corners of the lips, which move upwards) and the *orbicularis oculi* (a muscle surrounding the eye that causes the eyes to wrinkle). According to Ekman et al. (1990), only smiles involving the activation of these two muscles are considered to be genuine consequences of amusement. Phony smiles, which are forced and controlled smiles, do not involve the orbicularis oculi, which is how they can be distinguished from genuine smiling. Thus, when studying the emotional response to humorous stimuli, it is recommended that the Facial Action Coding System (FACS; Ekman & Friesen, 1978), or automated programs such as AFFDEX or FACET (Stöckli et al., 2018) are used to code precisely whether the zygomaticus major and orbicularis oculi muscles are involved, and thus, whether a perceived smile can be considered as an uncontrolled genuine response to humor.

1.3.2 Laughter

Similarly to smiling, laughter can briefly be described as a behavioral response to different types of *triggers*, such as humor, jokes, social interactions, but also fear and shyness, which can include a *physical response* involving respiration, facial actions, acoustics, and body movements (Ruch and Ekman, 2001); these behavioral responses can lead to positive affect, emotion regulation, or social interaction regulation *outcomes*. Laughter is thus a highly complex phenomenon as it depends greatly on the context (e.g., social or non-social), seems to serve different functions (emotional and social), and is triggered by several types of stimuli. Indeed, laughter is not necessarily an answer to humor. Researchers have distinguished between two types of laughter: voluntary and involuntary. *Involuntary*, or spontaneous laughter, is the first to emerge during infancy (Mireault, 2022). One element that accounts for the differentiation between laughter and humor is that the former develops much earlier in the lifespan than the latter. Indeed, laughter emerges at around 4 months of age (Hoicka & Akhtar, 2012), showing that it is not necessarily related to formal humor processing. Involuntary laughter can be described as being driven by outside events, not deliberate, and difficult to inhibit. Acoustically, it sounds closer to animal signals. *Voluntary* laughter, on the other hand, could be described as a more complex type of laughter. “Voluntary” does not mean that it is necessarily fake, but rather that it can be controlled and inhibited. Its production involves the neural and motor systems related to speech production. Thus, it is closer to speech-like sounds and even tends to accompany speech, whereas involuntary laughter tends to override it (Mireault, 2022; Scott et al., 2014; Wood & Niedenthal, 2018). An important difference between these two types is that “involuntary laughter reveals an *affective* state, while voluntary laughter reveals a *social* agenda” (Mireault, in press.).

Whereas laughter can be a behavioral response to humor, it appears that a majority of laughter episodes are not related to jokes or amusing content, but rather serve a social function in interaction. In fact, laughter has been largely studied by sociologists, who have underlined its importance as a form of communication in itself (Kuipers, 2008). Laughter is generally shared in a social context and is 30 times more likely to occur in social than in solitary settings (Provine, 2017; Provine & Fischer, 1989). Interestingly, laughter occurs more often from the speaker than from the audience (Provine, 2000). Therefore, it seems as if laughter plays an important role in interpersonal relationships and that it does so in different ways. Thus, Wood and Niedenthal (2018) distinguished between three social functions of

laughter. First, laughter can serve as a *reward*, to the producer as well as the recipient. Notably, it can be rewarding as it releases opioids, can induce positive affect, and regulate negative emotions. Second, some types of laughter do not necessarily induce positive emotions but serve an *affiliative* social function, regulating and encouraging interaction by signaling harmless intentions and thus avoiding the misinterpretation of threat. The authors (Wood & Niedenthal, 2018) list a series of affiliative types of laughter, such as conversational laughter, polite laughter, speech-laughter, sexual interest laughter, and embarrassed laughter. Third, they distinguish *dominance* laughter, which is a way of signaling a conflict or reprimand of someone's behavior in a more socially acceptable way than directly aggressing the person; thus, it avoids jeopardizing the social bond. Although the distinction between voluntary/social and involuntary/emotional laughter is important for demonstrating that laughter operates different functions, the border between laughter related to humor and that related to social interaction is probably not that strict. Indeed, laughter in an interaction can convey important information between the communicators: it can be seen as a sign that the interaction has shifted to the humorous mode and is a way of explicitly communicating the acceptance of a joke (Kuipers, 2008). As such, even involuntary laughter seems to serve a social purpose, as it expresses one's state of mind in relation to a humorous interaction.

Laughter thus plays an important role in social interaction in various ways. However, even though research has shown that laughter is, most of the time, not triggered by jokes or humorous content, it still often results in laughter. As such, studying individuals' responses to humor can provide great insight into their relationship to *involuntary laughter*. Conversely, laughter seems to be a good indicator of the intensity of the amusement (Ruch, 1995). It is generally acknowledged that genuine laughter includes a Duchenne smile, as well as acoustic exhilaration and bodily vibration, which can vary in intensity (Ruch & Ekman, 2001). Although the morphology of genuine involuntary laughter is not precisely described as Duchenne smiling (Ekman & Friesen, 1978), by using individuals from different cultures and languages, Bryant et al. (2018) have shown that fake (volitional) and genuine (spontaneous) laughs can be distinguished from one another. As such, as a response to humorous stimuli, genuine laughter and a genuine smile can be similarly detected and used as an indicator of a person's level of amusement in studies of humor.

Having briefly reviewed the cognitive, behavioral, and intrapersonal characteristics of humor, the next section presents some functions of humor, to highlight why the study of

humor is so important. It addresses how humor can contribute to enhanced well-being but also has a dark side.

1.4 Functions of humor

The study of humor is particularly important because it operates a variety of social and emotional functions. Indeed, it can foster social interactions in various ways and contributes to the regulation of one's own and other people's emotions. This section of the thesis defines the main functions of humor, with a special focus on its role in emotion regulation. It lays the foundations for understanding why it is crucial to better grasp the particularities of humor processing in specific neurodevelopmental conditions, to be able to foster the use of humor in individuals with specific socio-emotional and cognitive profiles.

1.4.1 Social functions of humor

Humor serves several social functions. Kuipers (2008) points out that sociological research on humor has revealed that it ensures three main social functions: (1) social order, (2) social control, and (3) social cohesion. Indeed, humor can be used to maintain social order by relieving tension in the case of conflicted or contradictory social situations. It can also act as a form of social control: by making fun of transgressions, individuals indirectly state their adherence to certain values. Finally, humor has a cohesive function, in the sense that it reduces the social distance between individuals to create a connection, notably by implying a form of invitation to begin and/or maintain an interaction (Kuipers, 2008). In other words, humor can bring people together, contribute to "breaking the ice," and motivate individuals to want to get to know each other. Moreover, by bringing individuals together, humor contributes to building a group identity: it reinforces group norms and increases group cohesiveness (Martin et al., 2003). Thus, not only does humor *bring* people together, it also seems to *keep* them together and contribute to the duration and appreciation of interactions. Indeed, humor has been shown to increase the length of time and amount of pleasure felt during social interaction, as well as to improve self-confidence in communication (Nezlek & Derks, 2001). Finally, humor contributes to enhancing social interactions because it makes people look good. Indeed, Treger et al. (2013) have shown that humor correlates positively with liking and closeness, confirming its role in forging social bonds. Humor is thus important in everyday human life and can be highly important for forging and maintaining a social life.

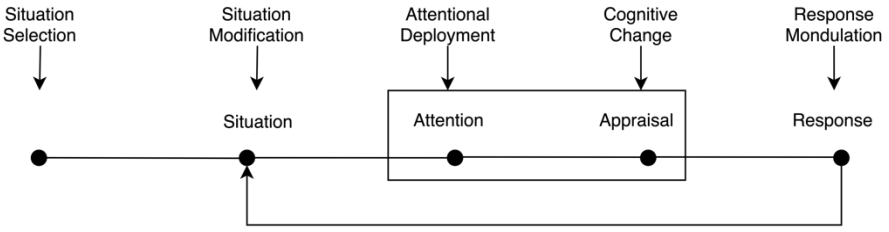
1.4.2 Humor for well-being and emotion regulation

When it is appropriate and adaptive (Kuiper et al., 2004), humor can enhance well-being, as it not only serves to foster social interactions, it also triggers positive emotions and regulates negative emotions. Indeed, humor is one of the core character strengths as measured by the Values in Action Inventory of Strengths (VIA-IS; Peterson & Seligman, 2004). The VIA-IS is derived from positive psychology and aims to describe human strengths, rather than focusing on their difficulties or pathologies (Ruch et al., 2010). Peterson and Seligman (2004) define six universal virtues and 24 character strengths that represent the mechanisms that lead to these virtues. One of the virtues is *transcendence* and the strengths connected to it are described as "strengths that forge connections to the larger universe and provide meaning" (Peterson & Seligman, 2004, p. 30). Humor is one of the strengths attached to transcendence (together with the appreciation of beauty, gratitude, hope, and religiousness). According to this universal virtues model, laughing, joking, and bringing smiles to others allow individuals to see the lighter side of issues and transcend the meaninglessness of life (Peterson & Seligman, 2004). As such, humor is described as a core strength for achieving well-being and happiness. Generally, research has described the potential of humor to strongly contribute to life satisfaction and resiliency (Kuiper, 2012; Peterson et al., 2007). Indeed, humor can be seen as an important component of psychological well-being, notably through its emotion regulation function, as it can down-regulate the negative emotions that may provoke distress and difficulties and up-regulate the positive emotions that contribute to happiness and well-being (Amjad & Dasti, 2022; Horn et al., 2018; Samson et al., 2014).

Gross (1998, 2015) defined five families of emotion regulation strategies, based on the *modal model* of emotion. Broadly, this model states that emotions arise from a relevant situation (external or internal) on which we deploy our attention to proceed to an appraisal of the situation (i.e., an individual and subjective assessment), which will finally give rise to an emotional response. This model operates as a loop since the emotional response will, in turn, influence the given situation. Based on this, Gross (1998, 2015) built a *process model* of emotion regulation, which also includes five families of strategies that operate according to specific stages of the emotional sequence (see Figure 3).

Figure 3

Process model of emotion regulation



Note: Retrieved and adapted from Gross and Thompson (2007).

Under this model, one can select the situation, modify the situation, manage the attention deployed, cognitively change the appraisal of the situation, or modulate the emotional response. Regarding the use of humor as a tool for regulating emotions, humor can occur in two families of emotion regulation: attentional deployment and cognitive change.[5] Attentional deployment consists of redirecting the attention, either away or closer to the situation. There are two main types of attentional deployment: distraction and rumination. Distraction consists of an attentional shift away from emotional issues related to the situation, whereas rumination consists of focusing attention toward the thoughts and feelings related to the emotional situation (Gross, 2008). Cognitive change occurs in the appraisal sequence, whereby a person can modify their way of thinking about an emotional situation, which will change the meaning they give to it and influence the emotional response.

Based on this model of emotion regulation (which is one amongst others), researchers have observed that humor notably contributes to regulating negative emotions as a result of cognitive distraction. Strick et al. (2009) have shown that cognitive demands related to the incongruity-resolution process oblige individuals to focus their attention on a cognitive task other than the one that elicits negative emotions, thus attenuating the negative emotions. Humor also serves as an emotion regulation strategy through cognitive reappraisal; it helps to reevaluate the situation from another perspective, to make it less negative and/or more positive. Humorous reappraisal has been proven to be effective in experimental settings. For example, Samson, Glassco, et al. (2014) showed that compared to serious reappraisal (i.e.,

[5] Response modulation would rather concern laughter and smiling, which, as we have seen, can be but are not necessarily related to humor.

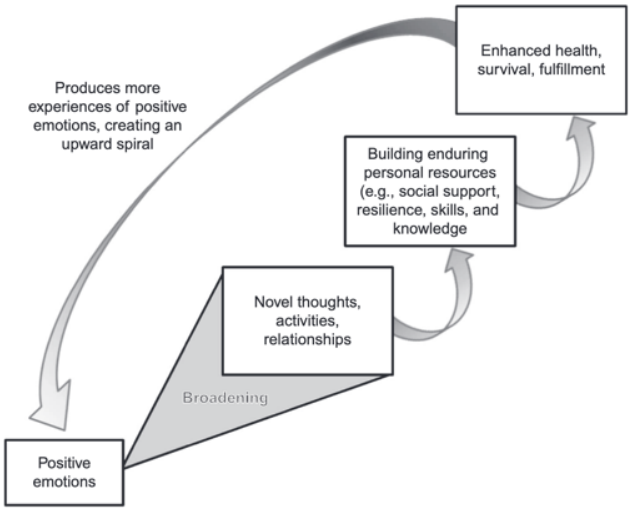
a cognitive reappraisal based on non-humorous content), humorous reappraisal was more efficient for increasing positive emotions and down-regulating negative emotions elicited by negative pictures. This was confirmed by Kugler and Kuhbandner (2015), who used a similar paradigm to show that humorous reappraisal was more efficient than serious reappraisal for regulating elicited negative emotions. Moreover, these authors tested the effects of the two types of reappraisals after the emotion was regulated. After a little distraction time, participants took a free-recall test, where they were asked to describe as many pictures as they remembered. They then took a memory test regarding a series of already seen and unseen pictures, where they had to answer as quickly as possible whether or not they had seen the picture before. Interestingly, compared to the non-appraisal condition, participants had a reduced score on the free-recall test for both the serious and humorous reappraisal conditions. However, they showed a stronger memory strength (ability to differentiate between seen and unseen pictures) for the humorous-reappraisal condition. These results show the powerful functional effects of humor production on the regulation of negative emotions, as it can contribute to the assessment of the situation differently without denying or forgetting the reality.

The studies described above highlight the effectiveness of humorous content produced to down-regulate emotions. Furthermore, it is by producing a form of humor oneself and not merely being a spectator that one can efficiently benefit from using humor as an emotion regulation tool. This use of humor is about helping oneself to view a situation differently; it is not about making other people laugh (Papousek, 2018). This is not to say that trying to cheer another person up by telling a good joke is not beneficial. In the short-term and the moment, it can help to distract the person from a negative situation (Papousek, 2018; Samson & Gross, 2012). Humor production, however, seems to have a greater long-term impact on psychological well-being. More precisely, it is the regular and *habitual* production of humor—and not merely its isolated production—that has the most positive impact on psychological well-being (McGhee, 2010; Papousek, 2018). Curran et al. (2021) also stressed the positive correlation between humor orientation (i.e., the degree to which individuals habitually engage in humor in social interactions) and general mental well-being. They even showed that humor orientation positively impacts physical health, since it turned out to be negatively correlated with headaches. But again, it is important to stress that it is the *habitual* orientation towards humorous interaction that leads to positive outcomes in the long-term, and not isolated events of shared laughter.

Humor not only serves as a tool to down-regulate negative emotions, it also serves to up-regulate positive emotions (Geisler & Weber, 2010; Samson et al., 2014). Indeed, producing or consuming humorous content can trigger positive emotions (Kuiper, 2012). According to Fredrickson's broaden-and-build theory of positive emotions, experiencing positive emotions leads to wider perceptual access (Fredrickson, 2013) and broadens an individual's thought–action repertoire (Fredrickson, 2004), making them more open to new experiences, novel thoughts, and building relationships. Such experiences contribute to building more solid personal resources, such as resilience skills or social support networks, which directly contribute to enhancing psychological well-being and health. This state of improved well-being and health leads individuals to be more open and receptive to positive emotions, which renders the broaden-and-build theory a virtuous cycle, as depicted in Figure 4.

Figure 4

The broaden-and-build theory of positive emotions



Note: Retrieved from Fredrickson (2013, p. 16).

It is important to note, however, that the effects of humor on emotion regulation depend on the type of humor involved, more specifically on its valence. Humor has been shown to have a greater impact on regulating emotions when it is positive as opposed to negative humor. Samson and Gross (2012) presented participants with negative pictures and asked them to rate their level of positive and negative emotions. They were then asked to view the same pictures again and either just watch them (control condition), or use positive

humor (positive condition) or negative humor (negative condition) to down-regulate the emotions elicited by the picture. Positive humor was described to the participants as being benevolent, sympathetic, and not depreciating, whereas negative humor was described as being hostile and based on mocking others in a depreciative way. The results not only confirmed that humor was an efficient tool for down-regulating negative emotions, but also that positive humor was more efficient than negative humor for doing so. Similarly, Cann and Collette (2014) examined the impact of different humor styles on well-being and showed that the habitual use of self-enhancing humor contributed to a stable positive affect state (which they called a "merry heart"), which is associated with psychological well-being and resiliency. In contrast, the use of negative, aggressive humor has a negative impact on happiness and well-being (Ford et al., 2014; Papousek, 2018).

1.4.3 The dark side of humor

Humor undoubtedly has a considerable positive impact on psychological well-being, but it also has a dark side (Samson & Gross, 2014). Kuiper (2012) has highlighted the importance of considering both the positive and negative impacts of humor when studying it from a positive psychology point of view, reminding us that not all types of humor necessarily contribute to resilience and a heightened sense of well-being. Adaptive (positive) humor styles correlate positively with adaptive emotion regulation and well-being, whereas maladaptive (negative) humor styles seem to be positively related to maladaptive emotion regulation and negatively related to well-being (Amjad & Dasti, 2022).

As previously discussed, not all types of humor are benevolent, harmless, and well-intended (Martin et al., 2003). Some are hurtful, such as ridicule or negative mockery. Ruch and Proyer (2009) depicted three dispositions towards laughter and ridicule: gelotophilia (the joy of being laughed at), gelotophobia (the fear of being laughed at), and katagelasticism (the joy of laughing at others). Whereas the first is quite positive, the other two can have negative consequences on the target being mocked and ridiculed. Katagelasticism is a disposition that is closely related to schadenfreude—malicious joy—which depicts the positive emotion felt through enjoying others' misfortune and notably includes the tendency to enjoy laughing at others' misery (Smith et al., 2009). In this case, the mockery is positive for the perpetrator, but unless they are a gelotophile, the target is much more likely to have a negative experience, which, in the case of gelotophobes, can lead to a generalized fear of being laughed at (Ruch & Proyer, 2008a). Gelotophobia can lead to a general tendency to interpret

others' laughter as being directed toward oneself, even when this is not the case, and to have difficulties enjoying any kind of laughter (Titze, 2009). The consequences of such fear can lead to elevated social fears and a retreat from social life. Although gelotophobes experience particularly strong negative emotions when confronted with mockery, whether it is mean or good-natured (Platt, 2008), ridicule and mockery can have a negative effect on anyone, even if they are not a gelotophobe. Indeed, these types of humor can be important elements of bullying. The border between good-natured teasing between friends and ill-natured harassment is quite thin (Kowalski, 2007), and in bullying situations, humor can be an ally as well as an enemy (Klein & Kuiper, 2006). It is thus crucial to understand the relationship between laughter and humor, since for some individuals and in some cases, they can lead to negative experiences. As such, although humor is generally seen as a vehicle for enhancing well-being and fostering social interactions, its dark side can have significant damaging consequences on one's well-being and social life, and hence, it should not be ignored in humor research.

Now that some important elements for understanding humor have been reviewed, the next section of this chapter briefly describes the main characteristics of the neurodevelopmental conditions that are the main focus of this work. The following chapters then examine what research has brought to our knowledge of humor in these neurodevelopmental conditions, and conclude with the goals of the thesis.

1.5 Neurodevelopmental conditions

Neurodevelopmental conditions (i.e., neurodevelopmental disorders) manifest early in childhood and influence neurocognitive development (Morris-Rosendahl & Crocq, 2020). They "involve significant difficulties in the acquisition and execution of specific intellectual, motor, language, or social functions" (ICD-11; World Health Organization, 2022). The DSM-5-TR (APA, 2022) describes three neurodevelopmental disorders: intellectual developmental disorder (i.e., intellectual disability), autism spectrum disorder, and attention deficit hyperactivity disorder. These conditions often co-occur and can be associated with genetic syndromes, such as Down syndrome or Williams syndrome, which present with intellectual disabilities. Intellectual disabilities are defined as deficits in cognitive abilities, such as problem-solving, abstract thinking, reasoning, or learning from experience, which result in difficulties in adaptive functioning (i.e., adaptive functioning refers to the practical and social

skills that allow a person to meet the standards of personal independence). The onset of these intellectual disabilities and adaptive deficits occur during the developmental period (i.e., during childhood) (American Psychiatric Association, 2022).

The main focus of this thesis is on two neurodevelopmental conditions, namely autism spectrum disorder and Williams syndrome, with a third, Down syndrome, included for reasons that will be made clearer later. It also takes on a transdiagnostic perspective to surpass a simplistic diagnosis perspective.

1.5.1 Autism spectrum disorder

Autism spectrum disorder (ASD; commonly referred to as "autism") is a neurodevelopmental condition, the diagnosis of which cannot yet be determined by reliable biomarkers, but is based on observable behavior (Lord et al., 2018). The DSM-5-TR describes ASD symptoms as involving deficits in social communication and interaction and restricted interests and repetitive behaviors (APA, 2022). Table 2 shows the main criterion for the diagnosis of autism as described in the DSM-5-TR (the detailed version of the criterion that includes ranges and examples can be found in Appendix 1). The DSM-5-TR also suggests there are different levels of severity for both the social communication deficits and restricted, repetitive behavior: (1) "requiring support," (2) "requiring substantial support," and (3) "requiring very substantial support" (APA, 2022).

Table 2

Diagnosis criterion for autism spectrum disorder.

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by all of the following, currently or by history:
    1. Deficits in social-emotional reciprocity.
    2. Deficits in nonverbal communicative behaviors used for social interaction.
    3. Deficits in developing, maintaining, and understanding relationships.
B. Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history:
    1. Stereotyped or repetitive motor movements, use of objects, or speech.
    2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior.
    3. Highly restricted, fixated interests that are abnormal in intensity or focus.
    4. Hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment.
C. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities, or may be masked by learned strategies in later life).
D. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.

E. These disturbances are not better explained by intellectual developmental disorder (intellectual disability) or global developmental delay.

Note: Retrieved from the DSM-5-TR (American Psychiatric Association, 2022) and shortened by the author.

Different prevalence rates of autism have been reported over the years and across the world (Chiarotti & Venerosi, 2020). The prevalence differs according to the different studies, and more importantly, the different parts of the world they were conducted in. Reviews have reported worldwide median prevalence rates. For example, Elsabbagh et al. (2012) reported a worldwide median prevalence of 62 out of 10,000 people, while more recently, Zeidan et al. (2022) reported a median prevalence of 100 out of 10,000 people worldwide and in Europe. There is an important differentiation between males and females in the prevalence rate of autism; being male seems to be an important etiological factor for autism, with a worldwide median male-to-female ratio of 4.2 (Loomes et al., 2017; Zeidan et al., 2022).

As defined in the DSM-5-TR, autism includes a large heterogeneity of intellectual abilities. Indeed, autism can, but does not necessarily, co-occur with intellectual disabilities. Worldwide, it has been reported that a median of 33% of autistic individuals also present with intellectual disabilities, while in Europe the median figure is 20.9% (Zeidan et al., 2022). However, a more homogenous pattern has been described in ASD in terms of cognitive skills, notably in relation to executive functions (Ozonoff et al., 1991). Executive functions are cognitive mechanisms that allow people to adapt an instinctive behavioral response to a given situation by paying high attention to it, utilizing mental models, and taking into account future perspectives (Diamond, 2013; Miyake et al., 2000). The core executive functions are inhibitory control (the ability to control and regulate a reaction), working memory (the ability

to store information and link old memories to new ones), and cognitive flexibility (the ability to "think outside the box"). Higher-level executive functions include reasoning, problem-solving, and planning (Diamond, 2013). Through years of research in the domain, autistic individuals have consistently been reported as showing difficulties in all domains of executive function (Demetriou et al., 2018). Additionally, autistic individuals have been described as having a "weak central coherence", as they seem to have difficulty retrieving the relevant information to form the "big picture", and instead, they focus on and remember the details, which are sometimes irrelevant to the adaptive interpretation of a situation (Happé, 1997). These cognitive particularities directly influence the behavioral responses of autistic individuals to a given situation and partially explain why they tend to engage in apparent maladaptive behaviors. However, more recent studies have nuanced this generalized local processing (Plaisted et al., 2003) and have notably highlighted that it depends on dimensions that are measured, more specifically whether the tests accessing the level of central coherence involve visual-spatial or linguistic dimensions (Bojda et al., 2021; Brock et al., 2008; Pellicano et al., 2005). As such, it seems that autistic individuals seem to differ in their level of central coherence depending on the dimension measured, thus invalidating the conception of a universal weak central coherence in ASD (López et al., 2008). Moreover, the relations, correlations, and differences between these different cognitive specificities that are central coherence, theory of mind and executive functions are still under debate in the literature (Booth et al., 2003; Pellicano et al., 2005).

ASD can also co-occur with other neurodevelopmental conditions, the most common of which is attention-deficit/hyperactivity disorder (ADHD), and with psychiatric disorders, such as anxiety disorders and depression (American Psychiatric Association, 2022; Lord et al., 2018). It has been reported that 28.2% of autistic individuals also present with ADHD and that 29.2% present with a social anxiety disorder (Simonoff et al., 2008). Anxiety is particularly concerning for autistic individuals, who have been continuously reported as having higher levels of anxiety compared to TD individuals, and those with other clinical or neurodevelopmental conditions (van Steensel & Heeman, 2017). One important predictor of anxiety in individuals with ASD is difficulties with emotion regulation (Conner et al., 2020). A similar observation was made by Swain et al. (2015), who reported that emotion dysregulation, as well as social motivation, significantly predicted social anxiety. Indeed, difficulties with emotion regulation seem to be a typical characteristic of autism (Cai et al., 2018; Mazefsky et al., 2013). Emotion regulation difficulties have important consequences for

the life and well-being of autistic individuals, as they predict anxiety as well as maladaptive behaviors. Indeed, Samson et al. (2015) reported that individuals with ASD are less likely than TD individuals to use cognitive reappraisal as an emotion regulation strategy, which leads to an increased frequency of negative emotions and more maladaptive behaviors.

The first core criterion for ASD states that autistic individuals present with social communication difficulties. Research has long highlighted the difficulties that autistic individuals experience with social cognition, in particular with theory of mind. Indeed, historically, autistic individuals have been described as having difficulty understanding others' mental states (Baron-Cohen et al., 1985; Happé, 1993), which notably, has been reported as an apparent reduced level of empathy (Lawson et al., 2004). However, more recent studies have failed to replicate and confirm a strict theory of mind impairment in autistic individuals. Indeed, in the laboratory, they are able to solve false belief tasks (Gernsbacher & Yergeau, 2019), although they still appear to show less spontaneous theory of mind (Senju, 2012); this suggests that their observed difficulties with reading other people's mind do not seem to be related to intrinsic cognitive impairments (Livingston et al., 2019). The more recently developed social motivation hypothesis proposes that the difficulties that autistic individuals experience in the social domain might be related to diminished social motivation, which relates to "a set of psychological dispositions and biological mechanisms biasing the individual to preferentially orient to the social world (social orienting), to seek and take pleasure in social interactions (social reward), and to work to foster and maintain social bonds (social maintaining)." (Chevallier et al., 2012a, p. 231)

What the social motivation hypothesis adds to our understanding of social difficulties in autistic individuals is that they might not have intrinsic difficulties understanding the social world (e.g., cognitive impairment in understanding other people's mental state), but instead, their difficulties seem to be related to diminished social interest, which in turns reduces the amount of social input that contribute to building up general social abilities (Chevallier et al., 2012a). In other words, because we learn by doing, individuals who seem to be less inclined to seek out social interaction might have fewer learning opportunity for reading social clues, which results in unusual and maladjusted social interactions.

ASD is a particularly heterogeneous condition and a whole thesis could be dedicated to describing all the studies that have contributed to achieving a better understanding of the spectrum. These few paragraphs, however, highlight some of the important characteristics

of autism that are particularly of interest when studying autistic individuals' relationship with humor from a social, cognitive, and behavioral point of view. The next section describes some important characteristics of Williams syndrome and the domains tackled to describe ASD, to present their specific cognitive and socio-emotional profiles.

1.5.2 Williams syndrome

Williams syndrome (WS) is a rare genetic disorder that occurs due to a deletion on chromosome 7q11.23 and affects approximatively 1 in 10,000 births (Morris & Mervis, 2021). It is characterized by several physical, cognitive, and behavioral characteristics. On a physical level, individuals with WS have distinctive facies and a variety of physical difficulties, such as cardiovascular diseases (supravalvar aortic stenosis, mainly), as well as connective tissue, growth, and endocrine abnormalities (Morris, 2023). On a cognitive level, individuals with WS have generally mild to moderate intellectual disabilities (Korenberg et al., 2000). Relative to their intellectual disabilities, their level of receptive vocabulary and grammatical abilities have been reported as being higher than expected (Mervis & Robinson, 2000), indicating that language seems to be a strength in the cognitive profile of individuals with WS. However, the claim that their language abilities are above (and thus distinct) from their general cognitive level has been widely criticized, and instead, it is suggested that their language abilities match their general mild cognitive disabilities (Brock, 2007; Karmiloff-Smith et al., 1997; Mervis & Becerra, 2007). The only exception is relative to their receptive vocabulary performance (Brock, 2007; Robinson et al., 2003). On the other hand, individuals with WS also show pronounced difficulties in the domain of visuospatial construction (Farran & Jarrold, 2003; Heiz & Barisnikov, 2016; Morris & Mervis, 2021). This being said, reports indicate considerable heterogeneity in the cognitive strengths and weaknesses of individuals with WS, which questions the notion that WS has a syndrome-specific cognitive profile. Indeed, each individual with WS shows a particular cognitive profile, and *not all* have good verbal abilities and weak visuospatial capacities (Porter & Coltheart, 2005). Finally, on a cognitive level, individuals with WS have been reported to have difficulties with some elements of executive functioning, notably working memory and response inhibition (Greer et al., 2013; Menghini et al., 2010).

Individuals with WS often also meet the criteria for other psychopathologies. Indeed, 64.7% also meet the criteria for ADHD, and 53.8% experience specific phobias (e.g., fear of loud noises, the doctor/dentist, heights, etc.) (Leyfer et al., 2006). One particularity of the

socio-emotional profile of individuals with WS is that they seem to experience a particularly high rate of anxiety disorder; they experience more anxiety than individuals with heterogenous intellectual disabilities (Royston et al., 2017) and TD individuals, but less anxiety than autistic individuals (Rodgers et al., 2012). More specifically, individuals with WS typically experience specific fears and phobias rather than generalized anxiety (Dykens, 2003; Leyfer et al., 2006) or social anxiety (Leyfer et al., 2006; Rodgers et al., 2012). So far, little is known about emotion regulation in individuals with WS, although reports suggest that they do typically experience emotion regulation difficulties, and this seems to be related to poorer adaptive functioning (Brawn & Porter, 2018; Phillips & Klein-Tasman, 2009; Sideropoulos et al., 2023).

Individuals with WS also present a specific socio-emotional profile, which is mainly characterized by hypersociability—highly sociable behavior—and a bias towards exhibiting positive emotions (Järvinen et al., 2013; Tager-Flusberg & Sullivan, 2000). However, individuals with WS also present some difficulties in the socio-cognitive domain, notably with theory of mind (Tager-Flusberg & Sullivan, 2000), although variability in difficulty solving a false belief task has been observed, according to the specific cognitive profile of the individual (Porter et al., 2008). Specifically, Porter et al. (2008) reported that particular difficulties with theory of mind are found in individuals with WS who correspond to the cognitive profile characterized by strengths in verbal communication and weaknesses in the speed of information processing and spatial processing (i.e., Cognitive Subgroup 4, one of Porter & Coltheart's, 2005, most prevalent subgroups). To better understand why the mind-reading abilities of individuals with WS are not completely spared or impaired but present a more complex set of abilities and difficulties, Tager-Flusberg and Sullivan (2000) made the distinction between socio-perceptual and socio-cognitive components of theory of mind. They found that individuals with WS seem to have difficulty with the socio-cognitive component, which is related to the cognitive system typically assessed by the false belief tasks. However, the findings showed that they were quite spared on the socio-perceptual level, which is more connected to the affective system and contributes to the interpretation of facial and bodily expressions, as well as vocal prosody. Interestingly, the authors highlight that this difference in competencies between the perceptual and cognitive components of theory of mind for individuals with WS contributes to our understanding of the intrinsic paradox of their social profile. Indeed, they are typically gregarious, hypersociable, seek social interactions (Järvinen et al., 2013; Jones et al., 2000), and are generally described as

being extremely cheerful and smiling a lot (Tager-Flusberg & Sullivan, 2000). However, they also show difficulties in sustaining friendships (Gillooly et al., 2022) and seem to have general relationship difficulties, as reported by their parents[6] (Gillooly, 2018). Tager-Flusberg and Sullivan (2000) suggest that "their social responsiveness to others reflects social-perceptual sparing, whereas their poor social judgments and difficulty forming sustained friendships are part of their broader lack of sparing in cognitive aspects of theory of mind, especially higher-order theory of mind" (p. 80).

Despite evident difficulties in the socio-cognitive domain and some elements of social communication (such as joint attention or the use of gestures) (Laing et al., 2002), individuals with WS are typically described as high-level seekers of social interaction (Järvinen et al., 2013) with low-level social fears (Fisher, 2014), although the heterogeneity of the symptoms of WS play a role here again since the variability and severity of social approach behavior is noticeable across different individuals (Gillooly, 2018; Little et al., 2013). Three hypotheses have been proposed to explain this heightened social approach behavior in individuals with WS (Gillooly, 2018; Porter et al., 2007): (1) the social salience hypothesis suggests that they have a particularly high interest in social stimuli (Frigerio et al., 2006) coupled with a positivity bias that makes them more inclined to pay attention to positive faces (i.e., faces of people expressing happiness) (Dodd & Porter, 2010); (2) the amygdala hypothesis (Haas et al., 2009; Martens et al., 2009) suggests that they have abnormalities in the functioning of the amygdala, which, because it operates as a tool for emotion recognition, is highly important in detecting threats; and (3) the response inhibition hypothesis (frontal lobe hypothesis) (Little et al., 2013) suggests that the heightened social approach behavior of individuals with WS is related to a lowered ability to control their spontaneous behavioral response. In this thesis, one hypothesis is not favored over the others, since social approach behavior is not the main topic of this research. However, it is proposed that humor in individuals with ASD and WS should be examined by viewing the two syndromes as reflecting two extremes of a social motivation spectrum, which partly relies on the social salience hypothesis.

[6] Although self-assessment has revealed that individuals with WS consider they have close friends.

1.5.3 Two poles of the social motivation spectrum

On the surface, individuals with ASD and WS appear to have opposing socio-emotional profiles. Indeed, autistic individuals seem to be biased towards experiencing and exhibiting negative emotions (Samson et al., 2012), whereas individuals with WS instead show a bias towards experiencing and exhibiting positive emotions (Järvinen et al., 2013; Tager-Flusberg & Sullivan, 2000). Moreover, whereas autistic individuals present with social interaction difficulties as a core symptom (APA, 2022) and are described as showing a lower level of empathy (Lawson et al., 2004), individuals with WS are described as being particularly gregarious and empathic (Järvinen et al., 2013). However, there are some evident similarities between the two conditions (Asada & Itakura, 2012; Kirchner & Walton, 2021), notably, both have difficulties with social communication and cognition (APA, 2022; Laing et al., 2002; Senju, 2012; Tager-Flusberg & Sullivan, 2000), and emotion regulation (Phillips & Klein-Tasman, 2009; Samson et al., 2022; Samson, Hardan, Podell, et al., 2015). They also both have co-occurring psychopathologies, such as ADHD (Leyfer et al., 2006; Simonoff et al., 2008) or anxiety disorders (Rodgers et al., 2012; van Steensel & Heeman, 2017). As such, it would be incorrect to simply consider these two conditions as being strictly opposite in the socio-emotional domain.

However, there is one important difference between the conditions, and it relates to social motivation (Asada & Itakura, 2012). As described earlier, individuals with WS evidence abnormal social approach behavior and are highly motivated to seek social interaction (Gillooly, 2018), whereas autistic individuals evidence low social motivation (Chevallier et al., 2012a; Little et al., 2013). As such, these two conditions can be considered as two extremes of a social motivation spectrum, and therefore, it is of great interest to study them in parallel, notably when studying their relation to humor. Indeed, humor is intrinsically social and relies mainly on social interactions and the sharing of laughter (Provine, 2000; Reddy et al., 2002). As such, developing our understanding of the appreciation of different types of humor and the behavioral response to humorous stimuli in individuals with WS compared to autistic individuals would provide deeper insight into the cognitive and socio-emotional profiles of these conditions. It would also allow for a greater appreciation of the impact of specific socio-emotional profiles on humor processing in general. Such understanding and appreciation would contribute to the ongoing knowledge base on humor.

1.5.4 Down syndrome

The main focus of this thesis is humor in individuals with ASD and WS. However, a third group was included in two of the four studies examined here: namely, Down syndrome (DS). DS is a rare genetic disorder that concerns approximatively 1 in 800 births (Lanphear & Castillo, 2007). Similarly to WS, it generally involves mild to moderate intellectual disabilities (Antonarakis et al., 2020), although cases of profound intellectual disabilities have also been reported (Määttä et al., 2006). Individuals with DS have important similarities to WS in the social domain, in that they are also described as being hypersociable, gregarious, (Porter et al., 2007), cheerful (Grieco et al., 2015), and having a bias towards exhibiting positive emotions (Loyse & Barisnikov, 2008). There are also similarities between DS, WS, and ASD in that individuals with these conditions all have difficulties with social cognition and communication (Channell, 2020), and some executive functions (Carney et al., 2013). Thus, including a group of individuals with DS in this research allowed me to more precisely define whether the potential differences between ASD and WS are completely condition-specific or whether they rely more on a general socio-emotional profile. As such, including individuals with DS in this research allowed us to refine our understanding of the relationship between humor processing and high-level or low-level social approach behavior, and to clarify the influence on that humor processing of a bias towards experiencing and exhibiting positive or negative emotions.

1.6 Humor in neurodevelopmental conditions

1.6.1 Humor in individuals with autism spectrum disorder

When defining Asperger syndrome in 1944, Hans Asperger stated that children with this syndrome are characterized by a lack of sense of humor (Asperger, 1944). This statement seems to be somewhat implicitly accepted, at least in popular culture. The representation of the mathematic genius who is unable to understand second-degree statements and jokes seems to be somewhat anchored in the representation of autistic figures in popular cinema or TV shows. One perfect example is the character of Sheldon in *The Big Bang Theory*, who is unable to understand sarcasm, which becomes a recurrent joke, but learns how to recognize and use it thorough the course of the show. When I typed “autism+humor” into the Google search engine, the results consisted of a list of webpages with titles such as “Do

people with autism have a sense of humor?", "Do autistic people 'get jokes'?" Fortunately, things have evolved since Asperger's definition and instead, these websites defend the fact that while autistic individuals might have a different sense of humor than TD individuals, they definitely do not lack a sense of humor. Just out of curiosity (and because in 2023, Google is not our only "frienemy"), I asked ChatGPT "Do autistic individuals have a sense of humor?", and I got a manifesto for openness and respect as an answer, which I found both charming and frightening at the same time. Not only has popular thinking (and artificial intelligence) evolved regarding this question, but an increasing number of empirical studies have challenged and contrasted the initial idea that autistic individuals lack a sense of humor. Some of these studies are discussed below. However, it is essential to note that all the studies and research presented in the following section concern autistic individuals without intellectual disabilities.

Cognitive competencies

Studies have shown that autistic individuals do not lack a sense of humor but still present with a particular profile toward humor processing. For example, Samson and Hegenloh (2010) presented participants with cartoons involving different logical mechanisms and showed that autistic individuals found it more difficult than TD individuals to understand cartoons that require an understanding of the character's false belief, which involves theory of mind. Silva et al. (2017) presented participants with a series of pairs of pictures that were either neutral/humorous or neutral/neutral. After viewing these, participants were shown some of the pictures again and some new pictures, and asked whether they had already seen them or not (implicit measure). Finally, they were asked to rate the picture sequences on a 3-point scale of funniness (explicit measure). The results revealed that autistic individuals appreciated humor in much the same way as TD individuals on an explicit level (subjective ratings), but showed differences in the implicit level of humor processing (recognition task), which, in individuals with ASD, was revealed as being content-dependent. Indeed, compared to TD individuals, autistic individuals were less accurate in recognizing previously seen pictures when they depicted human content, but no group difference was found when animal content was depicted. These results suggest that autistic individuals have altered implicit humorous processing regarding social stimuli compared to non-social stimuli, which the authors present as being in line with the social motivation hypothesis, in the sense that autistic individuals seem less motivated to reach for social reward.

Two studies (Emerich et al., 2003; Ozonoff & Miller, 1996) have also revealed the general difficulty of autistic individuals to understand jokes: when presented with jokes and different endings and asked to assess which was the correct one, autistic individuals had more difficulties finding the correct ending than did TD individuals, which has been explained as an impairment in executive functioning (specifically cognitive flexibility) that make it more difficult to combine the surprise and coherence aspects of humorous content. While acknowledging the influence of cognitive flexibility, Lyons and Fitzgerald (2004) highlighted the influence of shifting abilities and working memory on the understanding and appreciation of humor in autistic individuals. Moreover, the authors pointed out that these difficulties might also be related to autistic individuals' weak central coherence, which prevents them from correctly integrating contextual information into the meaning of humorous content. Indeed, Purser et al. (2021) showed that when provided with contextual support, autistic individuals appreciate riddles at a higher level than when they do not have contextual support.

The above findings seem to suggest that autistic individuals have a generalized difficulty regarding the cognitive basis of humor, that is, with the incongruity-resolution process. However, Weiss et al. (2013) showed that when presented with simple types of slapstick humor that do not involve any inferential reasoning, theory of mind, or verbal ability, autistic individuals appreciate humorous stimuli in much the same way as TD individuals do, revealing that not only can autistic people solve incongruity-resolution problems, but that they can also appreciate humor and do not lack a sense of humor. In early research, Ricks and Wing (1975) revealed that autistic individuals seem to particularly appreciate slapstick comedy, while James and Tager-Flusberg (1994) showed that they can produce and appreciate simple types of humor that are not too cognitively complex, i.e., types of humor that typically emerge within the first year of life, such as tickling, funny sounds, teasing, simple riddles, or slapstick. In sum, rather than lacking a sense of humor, autistic individuals are more likely to have their own specific sense of humor. Their restrictive interests might make them more inclined to joke about topics that TD individuals might not initially find humorous. To be able to adequately grasp which types of humor autistic individuals engage in, future research should not only consider their difficulties with normative humor processing, it should also consider their unique humor style as being equally valid.

Individual characteristics

Particularities in the humor temperament of autistic individuals have been examined by Samson et al. (2013), who revealed that these individuals engage less than TD individuals in positive humor styles, i.e., self-enhancing and affiliative humor. The authors linked this particularity to impairments in social communication and cognition and suggested it could partially be related to emotion regulation difficulties. Within the TD population, autistic traits are positively correlated with negative humor styles (in particular, lower mind-reading ability scores) and negatively correlated with positive humor styles (Eriksson, 2013). Autistic individuals have also been reported as having a particular humor temperament, since they score lower on cheerfulness and higher on seriousness and bad mood (Ruch et al., 1996) than TD individuals (Samson et al., 2013). Lower-level cheerfulness and higher-level seriousness might impact autistic individuals' comprehension and appreciation of humor. It adds another layer to their difficulties with engaging in humor compared to TD individuals, which, as discussed above, is not only linked to cognitive difficulties but can also be related to a general temperament that "might reduce the motivation to search for a possible funny explanation when confronted with humorous materials" (Samson et al., 2013, p. 454).

Autistic individuals also evidence a particular relationship with others' laughter. It has been reported (Samson et al., 2011; Tsai et al., 2018; Wu et al., 2015) that autistic individuals present with a particularly high incidence of gelotophobia (i.e., the fear of being laughed at): 40% to 45% present with at least a slight level of gelotophobia, which is the highest rate found in any clinical group to date. As such, gelotophobia seems to be an important concern for autistic individuals. This has notably been explained by a lower level of extraversion in individuals with ASD, meaning that the development of gelotophobia in autistic individuals seems to be mediated by specific individual characteristics (Tsai et al., 2018). Future research should investigate which personality traits might be related to the development of gelotophobia in individuals with ASD, to better grasp the origins of this phenomenon and be able to help them better interpret other people's laughter.

Behavioral response

Interestingly, autistic individuals' particular relationship with laughter is also expressed in their production of laughs and smiles. Reddy (2002) revealed that autistic children, when compared to children with DS, laugh at a similar level in everyday life, but the

nature of their laughter differs in that they engage less in interpersonal laughter. Indeed, they are reported as producing more laughter involving content that is not shared with others. In other words, autistic children laugh as much as children with DS, but their laughs are not necessarily shared and are often solitary. Thus, autistic individuals' laughter does not seem to correspond fully to the normative projection of what the laughter response should be. Confirming this observation, Weiss et al. (2013) reported a form of dissociation between autistic individuals' smiles and laughs and their subjective reports of amusement. In their study, autistic individuals would sometimes laugh at stimuli they rated as low on funniness and would sometimes remain unexpressive to stimuli they considered to be funny, and not surprisingly, they also sometimes laughed at stimuli they considered to be humorous. As such, the authors reported a lower emotional coherence in individuals with ASD, in that their laughs and smiles did not purely and necessarily correspond to their level of amusement, as appeared to be the case in TD individuals.

To investigate the specificities of autistic individuals' laughter, Hudenko et al. (2009) analyzed the acoustical nature of autistic and TD children's laughs. In TD children, two types of laughs occurred at a similar degree: *voiced* laughs, which are tonal and involve the vocal cords (they typically include laughs that sound like "haha"), and *unvoiced* laughs, which are atonal and do not implicate the vocal cords (they are also referred as snorts and typically sound like "rrrr," "chhh," or "sss," or simple nose exhalation). In contrast, autistic children almost exclusively used *voiced* types of laughs. Interestingly, this type of laughter usually triggers positive emotions in the listeners (Bachorowski & Owren, 2001). Indeed, another study has revealed that naïve listeners rate autistic children's laughs more positively than TD individuals' laughs (Hudenko & Magenheimer, 2012), which indicates that autistic children seem to produce mainly the type of laughs that are highly engaging to listeners. The authors thus concluded that "consequently, if children with autism are producing laughs that are enjoyable to listeners, they may be encouraged to use these sounds to build positive social bonds with peers or caregivers" (Hudenko & Magenheimer, 2012, p. 651).

Functions of humor

Samson et al. (2022) assessed the use of different emotion regulation strategies on anxiety in individuals with various neurodevelopmental conditions during the COVID-19 pandemic. Their results suggest that only autistic individuals without intellectual disabilities (and not those with intellectual disabilities or individuals with WS) seemed to use humor as

an effective tool to regulate their anxiety levels. However, in autistic individuals with intellectual disabilities, the use of humor seemed to be related to an *elevated* level of anxiety. Although the authors call for a cautious interpretation of their exploratory study, they raise an interesting observation about the differences in the use of humor as an emotion regulation strategy between autistic individuals with and without intellectual disabilities. As mentioned above, most studies in the literature, and all those presented in this section, have been conducted with autistic individuals *without* intellectual disabilities, and little is known about humor processing in autistic individuals *with* intellectual disabilities. As such, future studies should enlarge their investigations toward autistic individuals with more diverse cognitive levels.

To enhance the use of humor as an emotion regulation strategy, interventions can be applied to increase the understanding, appreciation, and production of humor (Cai et al., 2014). Such interventions have been proven to be effective in autistic individuals without intellectual disabilities (Wu et al., 2016). Indeed, after several training sessions, autistic adolescents have a higher tendency to use affiliative humor and can understand and appreciate nonsense humor better. Such results indicate that autistic individuals can be trained to use humor as a tool to regulate negative emotions and decrease anxieties.

1.6.2 Humor in individuals with Williams syndrome

I tried again the exercise of typing humor search words into the Google search engine, specifically focusing on WS using the search term “humor+Williams+syndrome”. Interestingly, few popular websites referred to humor in WS; this does not seem to be a topic that is popularly tackled, which is surprising considering that one of the main descriptive characteristics of WS is their positivity bias and gregarious personality (Dodd & Porter, 2010; Hsu, 2020; Järvinen et al., 2013), which might be precisely the reason why their relationship with humor is not generally questioned. When I asked ChatGPT whether individuals with WS have a sense of humor, it told me they often have a highly developed and people-oriented sense of humor, due to their hypersociability. However, as I have tried to depict in this theoretical introduction to humor, it is cognitively very complex and laughter is not necessarily an answer to humor, nor even to positive emotions. As such, empirical research on humor and laughter in individuals with WS still needs to be enriched, which is not illogical considering the rarity of the syndrome and its discovery, which was only in 1961. To date,

limited research has been undertaken in this field, particularly on the social competencies linked to specific humor types.

Cognitive competencies

Research on humor in individuals with WS has mainly addressed their cognitive difficulties in relation to specific and particularly complex types of humor. Krishan et al. (2017) ran an experiment where they showed funny cartoons (the majority of which inferred a character's mental state to be understood) to participants with WS and DS, and other chronological age-matched and mental age-matched groups, asking them to explain the jokes. Individuals with WS performed below the chronological age-matched group, but similar to the DS and mental age-matched groups, which suggested that their poorer comprehension of cartoon jokes was related to their intellectual disabilities. The authors suggested that it might even be related to difficulties that individuals with WS and DS have with executive functions.

Regarding verbal humor, individuals with WS seem to have difficulties processing some forms of non-literal language. In a study by Sullivan et al. (2003), individuals with WS listened to stories that ended either in an ironic joke or a lie. Unsurprisingly perhaps, considering that irony is probably the most complex type of non-literal language, individuals with WS evidenced quite poor ability to adequately differentiate an ironic joke from a lie. They showed a general tendency to interpret all utterances as lies because they simply did not report the truth. The difference between the lie and the ironic statement in the presented stories was whether the main character intended to deceive another character (lie), or whether the main character knew the other character knew the truth and so was not trying to deceive them (irony). Thus, to distinguish between a lie and a joke, one has to have the cognitive ability to understand the main character's second-order belief about the other character's knowledge. However, irony is not the only form of non-literal language that individuals with WS seem to have difficulty understanding. Godbee and Porter (2013) reported that individuals with WS performed below chronological age-matched TD individuals in understanding non-literal language, specifically similes, metaphors, and sarcasm. However, the authors also reported that individuals with WS do not differ from mental age-matched TD individuals in their understanding of metaphors and sarcasm. The authors tested for the relationship between difficulties processing sarcasm and metaphors and general and specific cognitive abilities (i.e., expressive vocabulary, perceptual

integration, working memory, and inferential reasoning). For individuals with WS, there was no significant relationship between any of these cognitive abilities and their poorer cognitive ability to understand metaphors and sarcasm. Consequently, the authors suggested an interesting and intriguing possible interpretation according to which individuals with WS' sociable personalities and bias towards happy faces might affect their comprehension of sarcasm toward nicer and happier interpretations that rely in the literal interpretation (Godbee & Porter, 2013).

This interpretation corroborates with the interesting contradictory profile of individuals with WS, who appear to be highly sociable and positive, but also present with intellectual disabilities and difficulties with social cognition that make them more likely to misunderstand aspects of social communication and thus adopt a maladaptive behavioral response. Indeed, this underlines the importance of better understanding the social, emotional, and cognitive abilities of individuals with WS and how they relate to their specificities in communicating with other people.

The studies discussed above are, as far as I know, the only ones that have investigated humor comprehension in individuals with WS. They all focus on the difficulties they have understanding quite complex types of humor, focusing on either theory of mind or non-literal verbal comprehension. Although it is evident that individuals with WS have difficulty understanding these complex types of humor, it is not possible to use conclusions about these difficulties as a vehicle for comprehending their understanding of humor in general, i.e., their ability to solve the incongruity-resolution process. Additional research on the comprehension and appreciation of simple types of humor by individuals with WS is thus necessary.

Functions of humor

Samson et al. (2022) suggested that individuals with WS do not frequently use humor as an emotion regulation strategy in everyday life. Although the use of humor to regulate negative emotions does not seem to appear spontaneously in individuals with WS, Klein-Tasman et al. (2022) recently demonstrated the efficacy of induced play and humor-based therapy on fear management in children with WS. Nine children with WS took part in this study, which investigated play- and humor-infused therapy targeted at specific individual fears. The goal of the therapy was to expose the child to their specific fear in a playful and

humorous manner, to adapt their emotional reaction towards the target. Parents of eight of the children with WS gave weekly ratings on their child's specific fear (for between two weeks and 23 months, depending on the participant). For four of the children, the intervention proved to be effective over time for their management of specific fears and phobias. This pilot study was the first to indicate the effectiveness of humor in regulating strong emotional responses toward specific fears that are known to be an important concern in individuals with WS (Dykens, 2003). Such observation indicates that developing a better understanding of humor processing in individuals with WS is crucial and useful.

1.6.3 Humor in individuals with intellectual disabilities and Down syndrome

Although this thesis focuses on humor in individuals with WS and ASD, I would like to present a few research studies that have been conducted with individuals with intellectual disabilities, since individuals with WS and some autistic individuals also present with intellectual disabilities. Individuals with intellectual disabilities may present with a different set of cognitive disabilities, and as a consequence, appreciate humor differently. For example, and in line with studies already discussed regarding the cognitive specificities of individuals with ASD and WS towards humor, individuals with intellectual disabilities seem to appreciate humor in general, but show difficulties with certain types (in particular verbal humor) that require higher cognitive skills (for a review, see Chadwick & Platt, 2018). An early study demonstrated that individuals *without* intellectual disabilities understand cartoon jokes better than individuals *with* intellectual disabilities (Short et al., 1993). More recently, Degabriele and Walsh (2010) investigated humor comprehension and appreciation in school-aged children with mild or moderate intellectual disabilities. In this study, participants had to rate their level of appreciation of short scenes extracted from an episode of a children's cartoon. The scenes presented different categories of humor—physical, verbal, and visual—in comparison with a control condition with no funny elements. The results showed that children with intellectual disabilities appreciated more physical and visual humor than verbal jokes, even though they also showed a high level of appreciation for non-humorous cartoons, which were used as a control. To assess their comprehension, the jokes were told by an actress on video either with no support, or with different kinds of support, namely pictures, gestures, or acting. Jokes presented with gestures were significantly better understood by children with mild to moderate intellectual disabilities. Thus, individuals with intellectual disabilities do appreciate simple types of humor, but they have more difficulty comprehending more complex types of

humor compared to TD individuals. In particular, those with intellectual disabilities seem to appreciate less verbal humor, but appreciate it more when it is presented with gestures.

For individuals with intellectual disabilities, humor seems to be an important communication tool for social interaction. Indeed, Griffiths and Smith (2016) showed that individuals with severe intellectual disabilities often use smiles and laughter to regulate their communication with others. Johnson et al. (2012) also stressed the importance of humor in social interactions for the positive mood and well-being of individuals with severe intellectual disabilities. As they observed interactions between individuals with severe intellectual disabilities and other people, they identified two sub-categories of these "shared moments": "hanging out" and "having fun" together. The latter involves routines (rhythmic play, games, songs, and mimicry) and comedy (vulgarity, pranks, jests, and banter). As such, humor seems to play an important role in the everyday interactions of individuals with intellectual disabilities, although such individuals have difficulty understanding all kinds of humor typically used in the communications of TD individuals.

Since two of the four articles that are the focus of this thesis also include individuals with DS, I shall briefly review the research on humor in individuals with DS. Although the studies presented in this section examine individuals with DS, who present with intellectual disabilities, only a few studies have specifically focused on humor in DS and those that do have mainly involved a comparison with autistic individuals. St. James and Tager-Flusberg (1994) analyzed naturalistic humorous events in individuals with DS and ASD, showing that autistic children produce less humor than children with DS. They interpreted this difference in terms of deficits in the socio-cognitive aspects of humor in autistic children. Reddy et al. (2002) revealed that, whereas autistic children seem to show particular patterns in relation to humor, laughter, and humoristic interactions, as is discussed above, children with DS seem to show a relative standard development in different aspects of humorous interactions. As has been stated, "These aspects include: the individual's own humour and laughter at different sensory, interpersonal and socio-cultural events, responding to others' humour and laughter with interest, attempts to join in or attempts to re-elicit it through clowning and teasing" (Reddy et al., 2002, p. 235). Finally, more recently, Krishan et al. (2017) included individuals with DS in their study on the comprehension of funny cartoons involving theory of mind. They revealed that similarly to individuals with WS, individuals with DS had more difficulties understanding the jokes compared to a chronological age-matched group. These

few studies reveal that individuals with DS seem to present with a similar pattern of humor comprehension and appreciation to individuals with WS, but do not seem to experience the same differences and difficulties as autistic individuals. As such, these studies confirm that including individuals with DS as a third group makes sense to our investigation of the particularities of humor processing in the different conditions.

1.6.4 Humor in neurodevelopmental conditions: Section conclusion

This overview of studies on humor in individuals with different neurodevelopmental conditions has a particular focus on WS and ASD; it indicates that there is a general lack of research evidence on several components of humor in individuals with WS, compared to ASD. Indeed, no research has investigated the comprehension of simple humor (in the cognitive domain), the individual characteristics of humor, or the behavioral responses to humorous stimuli in individuals with WS. As such, the goal of this thesis is to strengthen the research base on humor in individuals with WS, as well as better understand what aspects of humor could be specific to individuals with ASD. The final section of this chapter presents the goals of my research, as well as some methodological considerations.

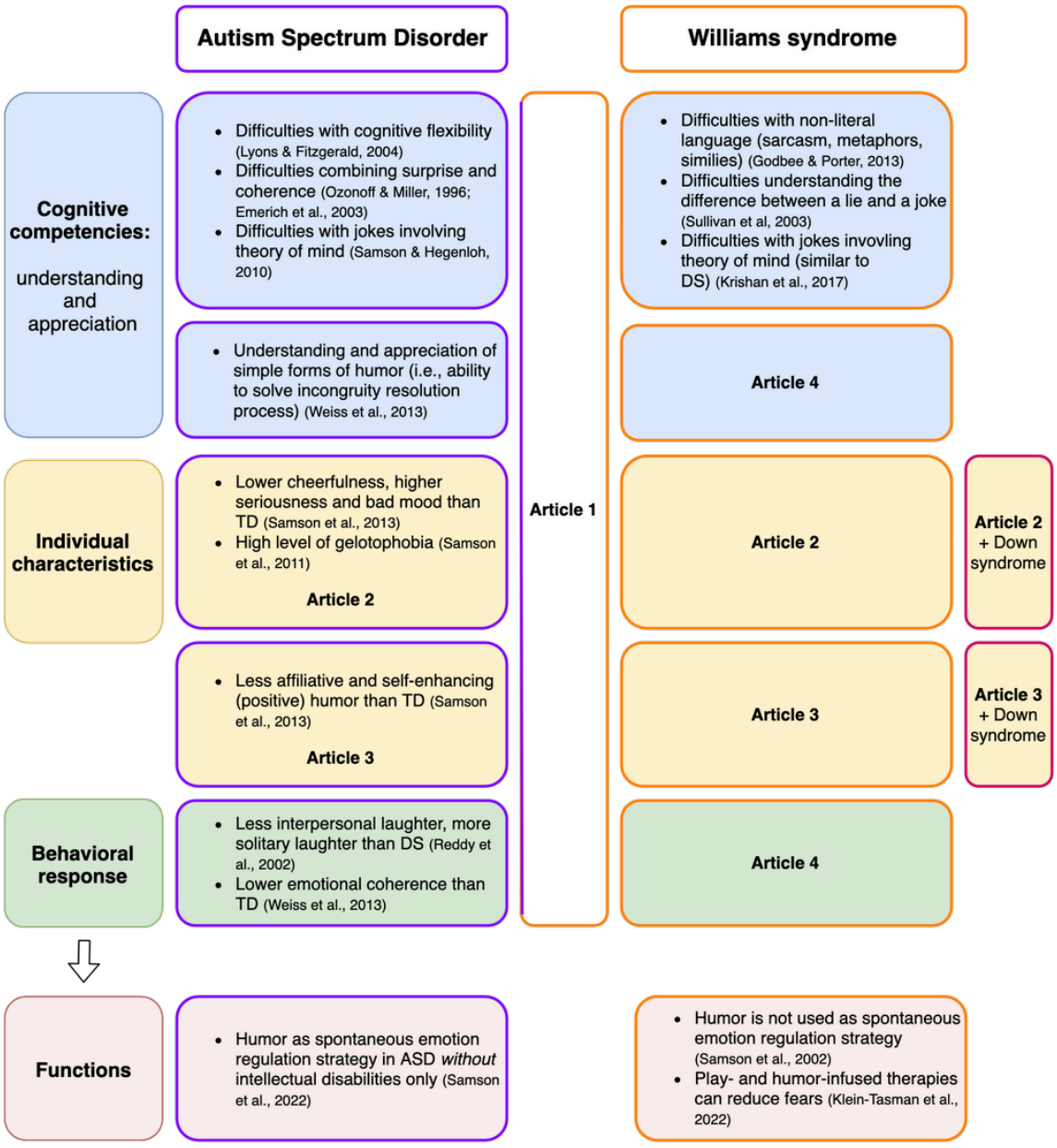
1.7 Aims and scope of the thesis

1.7.1 Theoretical goals

The research presented in this thesis focused on the understanding, appreciation, and response to humorous stimuli in individuals with ASD and WS. Considering the relative importance of the research findings on humor in individuals with ASD and the limited research into humor in individuals with WS, and that the two conditions can be viewed as two extremes of a social motivation continuum, this study had three main goals: (1) to shed light on humor in individuals with WS based on previous research that examined humor in individuals with ASD, and (2) to confirm or question previous conclusions on humor in individuals with ASD, and (3) to highlight the origins of specific relations to humor from a transdiagnostic perspective. Individuals with DS were also examined (based on two of the four included articles) to better grasp the specificities of different neurodevelopmental conditions that share similarities and differences with these two conditions.

Figure 5

State of the art: Overview and comparison of how humor in ASD and WS is currently understood in the scientific literature and of the theoretical goals of the thesis



Note: *ASD*, autism spectrum disorder; *DS*, Down syndrome; *TD*, typically developing; *WS*, Williams syndrome.

As depicted in Figure 5, this research was organized around the three main domains of humor research presented in this introduction chapter: cognitive competencies (which imply understanding and appreciation of different types of humor), behavioral response (which involves facial and bodily responses to humor, specifically smiling and laughing), and individual characteristics (which consider traits and behaviors that are described as fostering or limiting humor appreciation). Increasing knowledge in these areas contributes to the potential development of training programs, interventions, and humor-based therapies aimed at fostering the use of humor for social interactions, regulating emotions, and increasing psychological well-being.

Cognitive competencies

Generally speaking, research has shown that autistic individuals appreciate humor less than TD individuals (Samson, 2013b), although this depends greatly on the type of humor involved. As presented in Section 1.6.1, on a cognitive level, autistic individuals are typically reported as having difficulty understanding complex types of humor involving highly demanding cognitive skills, such as cognitive flexibility, inferential reasoning, or theory of mind (Emerich et al., 2003; Lyons & Fitzgerald, 2004; Samson & Hegenloh, 2010). However, they are able to understand and appreciate simple forms of humor as much as TD individuals (Weiss et al., 2013). As for individuals with WS, research on their relationship with humor has so far only focused on their difficulties understanding complex types of humor involving non-literal language and inferential reasoning, as well as theory of mind (Chadwick & Platt, 2018; Godbee & Porter, 2013; Krishan et al., 2017; Sullivan et al., 2003). However, as far as I can determine, no studies have investigated the understanding and appreciation of simple types of humor in individuals with WS. Gaining such knowledge would indicate whether these individuals can solve the incongruity-resolution process in the case of simple forms of humor, rather than that which involves the type of complex cognitive abilities that are more difficult for individuals with WS to process. I hypothesize that individuals with WS will be able to understand and appreciate simple forms of humor that do not require theory of mind, non-literal language, or any highly demanding cognitive ability, in much the same way as TD and autistic individuals do. Indeed, although individuals with WS typically have intellectual disabilities, these are generally mild to moderate (typically, most individuals with WS are verbal) (Kozel et al., 2021), meaning that the basic incongruity-resolution process should not

be impaired in the case of simple slapstick humorous material. This hypothesis is investigated and tested in Article 4 of this thesis.

Behavioral response

On a behavioral level, autistic individuals are presented as engaging less in interpersonal laughter and more in solitary laughter (compared to individuals with DS) (Reddy et al., 2002) and showing lower emotional coherence than TD individuals (emotional coherence holds that we laugh when amused and do not laugh when not amused) (Weiss et al., 2013). To date, and to my knowledge, no research has investigated the behavioral response to humorous stimuli in individuals with WS. Considering their hypersociability and high social motivation, I would expect individuals with WS to smile and laugh more in socially-shared contexts, in order to create bonding and maintain interactions. Additionally, based on arguments that they have a bias towards experiencing and exhibiting positive emotions and being generally cheerful, and considering how in popular culture, they are generally described and perceived as smiling and laughing a lot, individuals with WS might actually laugh and smile more than TD individuals, although their subjective experience of amusement might not differ from them. In other words, the laughter and smiling behaviors of individuals with WS might reflect more than a correlation with their level of amusement. Although the level of smiling and laughing in socially-shared contexts should be a topic of investigation for future research, the behavioral response of individuals with WS to humorous and non-humorous stimuli in non-social settings compared to that of TD individuals is investigated in Article 4 of this thesis. I hypothesize that they will smile and laugh more than TD individuals in both conditions and have less of a difference in their emotional response to humorous and non-humorous stimuli. In other words, individuals with WS might also present with emotional incoherence, in that they might express intense laughs and smiles independently of their subjective feeling of amusement.

Individual characteristics

Finally, in the study of individual characteristics that influence one's relationship with humor, research has presented autistic individuals as engaging less frequently in positive types of humor, being less cheerful and more serious, and more likely to be in a bad mood (as a trait) than TD individuals (Samson et al., 2013). They are also particularly prone to developing a fear of being laughed at (i.e., gelotophobia) (Samson et al., 2011; Tsai et al.,

2018). To my knowledge, no research has described the humorous temperament of individuals with WS, examined whether they have a tendency towards gelotophobia, or explored the extent to which they engage in different humor styles. These issues are the focus of Articles 2 and 3. In line with their general socio-emotional profile, I expect individuals with WS to show more cheerfulness, and less seriousness and bad mood, than individuals with ASD. I also presume that they might highly engage in affiliative and self-enhancing humor and have low-level self-defeating and aggressive humor styles, whereas the reverse might be the case for autistic individuals. Since they present with similar socio-emotional profiles, I expect the same pattern of humor style preferences in individuals with DS and individuals with WS. Individuals with WS and DS might also both experience gelotophobia, considering their general tendency to experience specific fears and phobias and their tendency to be bullied. On the other hand, they might also be protected from such a fear by their general cheerfulness and perceived positivity. Therefore, Article 2 of this thesis focuses on gelotophobia in individuals with WS, DS, and ASD. I expect individuals with WS to experience less gelotophobia than individuals with ASD, but to have a similar experience to individuals with DS.

Before presenting the results of the experimental and survey-based studies, Article 1, a conceptual article, presents what is known about humor in individuals with ASD and WS and suggests future lines of research. Articulated around the cognitive, social, and emotional components of humor, it includes (but is not limited to) some of the theoretical considerations presented in this introduction and explains how studying humor in individuals with neurodevelopmental conditions, in particular WS and ASD, can not only increase our understanding of these conditions but also our understanding of humor itself.

1.7.2 Methodological context

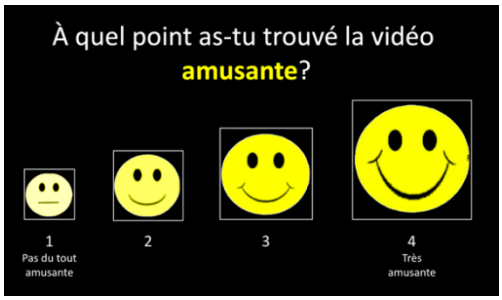
This thesis was conducted as part of Prof. Andrea Samson's Swiss National Science Foundation (SNSF) professorship project entitled "Socio-Emotional Processes and their Relation to Social and Non-Social Anxiety in Developmental and Intellectual Disabilities," which began in September 2018. The main objective of this project is described as follows: "Given the crucial role of social approach, positive emotions, and emotion regulation for optimal social and adaptive functioning, the goal of this project is to study these three phenomena in individuals with developmental disabilities with a particular focus on WS and ASD" (Samson, 2018)

The project was divided into two main research areas, one being on emotion regulation and the other on positive emotions. My research focused on positive emotions, and more specifically on humor, considering its role in positive emotions and Prof. Samson's area of expertise. However, emotion regulation remained an important aspect of this thesis, since I consider that gaining a better understanding of humor in neurodevelopmental conditions is the first step towards better understanding the role of humor in emotion regulation and its impact as a risk or protective factor against anxiety.

The studies presented in this thesis used two types of methodologies: experiments and surveys. Initially, three experiments were planned to investigate different and specific aspects related to humor. One was based on Samson and Hegenloh (2010), who studied the understanding and appreciation of how different types of visual humor rely on a specific logical mechanism in individuals with ASD. A second was based on Kreibig et al. (2015), which investigated the physiological response to stimuli triggering positive, negative, or mixed emotions. A third study was based on Weiss et al.'s (2013) research into the understanding, appreciation, and response to simple humorous stimuli in individuals with or without ASD. At the beginning of the project, the three tasks based on these studies were tested on a small number of individuals with WS. However, we rapidly realized that the tasks needed several adaptations, notably in relation to the scales that were used to measure the participants' subjective experiences. Indeed, it appeared that individuals with WS found it difficult to understand a 5-point scale depicted by an abstract design that was not presented to them before the experiment. As such, we developed a new 4-point scale with a clearer visual design (see the final scale in Figure 6), as well as a pretest and a training phase to ensure that the participants understood the scale properly (Hartley & MacLean, 2006).

Figure 6

The Likert-scale used to assess the level of amusement



Note: The scale was used in French and German (the experimental sessions took place in Switzerland). The figure depicts the French version. Translation: "How funny did you find the video? 1 = Not funny at all, 4 = Very funny."

The stimuli for the three tasks outlined above, which have been previously validated in adults (Kreibig et al., 2015; Samson et al., 2016; Samson & Hegenloh, 2010) and children (Weiss et al., 2013), were adapted for individuals with WS. For example, in the task involving videos that were supposed to induce negative emotions (Kreibig et al., 2015; Samson et al., 2016), some of the videos were clearly too negative to be shown to individuals with WS or TD children and had to be removed from the initial task. Additionally, 25 questionnaires were adapted and translated into English, French, and German.

Everything was ready for the field research, but then an unexpected hurdle arose: the COVID-19 pandemic. For a few months, the lockdown prevented us from running the experiments with the participants. Even after the social distancing requirements and restrictions were partially lifted, recruitment presented a major issue since individuals with WS have particular physical vulnerabilities. Indeed, it was not conceivable to put any of our participants at risk. Months passed and the project approached its deadline. It is important to specify that, considering the rarity of WS, we had to travel all over Switzerland to our participants' homes; this meant that it was not possible to collect a large amount of data in such a short period of time, and as a consequence, we revised the study's protocol, keeping only one experiment—that on simple humor. This experimental study was conducted with 12 individuals with WS, although four had to be dropped from the analysis. One of these failed to understand the scale correctly in the training phase and gave the same rating for all the stimuli; a second also gave the same rating for all the stimuli despite passing the training phase (therefore showing a lack of understanding of the scale); and the video recording failed for the other two, making further analysis impossible (because facial expressions were analyzed based on video recordings, as is presented in Article 4 of this thesis).

To compensate for the lack of experimental data, a more important focus was given to a parallel investigation that was based on parental-report questionnaires. Indeed, as part of the SNSF project, in collaboration with Dr. Jo Van Herwegen from the Institute of Education, University College London (UCL), in London, UK, we developed a large survey-based study called "Socio-Emotional Processes in Individuals with Neurodevelopmental Disorders." This project consisted of distributing questionnaires on emotions, emotion regulation, social approach, and humor in individuals with WS, ASD, and DS, and otherwise

non-specified developmental conditions. A total of 25 questionnaires were distributed to the parents of individuals with neurodevelopmental conditions all over the UK, and a total of 230 parents reliably participated. Initially, over 1,000 answers were recorded, but we realized that a great majority of these were scammer participants (motivated, perhaps by a voucher participants received for an online retail website); we detected these because they used the same IP address several times, always selected the same answer, were not coherent in their answers (e.g., date of birth and age did not match), or answered to each wave of the questionnaires in less than 10 minutes (there were between seven and 10 questionnaires per wave, for 256 to 312 items). However, we were still able to recruit a relevant number of participants, which notably allowed us to conduct analyses for Articles 2 and 3 of this thesis. Since I was the project administrator (my role was to set up the survey, coordinate communication, and manage the data), I was able to write my single-authored article (Article 3) based on the analysis originating from this collaborative project.

The studies presented in this thesis were funded by the Swiss National Science Foundation (SNSF Professorship PP00P1_176722, attributed to Prof. Andrea Samson) and the Research Funds of Unidistance Suisse. The main SNSF project protocol was validated by Geneva's *Commission cantonale d'éthique de la recherche* (CCER, Project-ID 2017-01435), and the survey-based study was validated by the ethics committee from *Unidistance Suisse* (Project-ID 2019-07-00002).

The next section presents a brief overview of the four articles that form the basis for this thesis.

1.7.3 Overview of the articles

Table 3

Overview of the articles constituting the thesis

Article 1: How cognitive, social, and emotional profiles impact humor appreciation: sense of humor in autism spectrum disorder and Williams syndrome.
Objectives: To build a conceptual overview of what is known about humor in individuals with ASD and WS. **Methods**: An overview of the relevant literature was applied. **Results**: This paper sheds light on how the particular cognitive, social, and emotional profiles of individuals with WS and ASD might affect their respective relation to humor.
Article 2: "Not in the mood": The fear of being laughed at is better predicted by humor temperament traits than diagnosis in neurodevelopmental conditions.
Objectives: This study investigated gelotophobia in ASD, WS, and DS, and assessed its possible association with individual characteristics. **Methods:** Questionnaires on gelotophobia, social difficulties, positive and negative affect, and humor temperament were distributed to the parents of young individuals (5–25 years of age) with ASD (N = 48), WS (N = 43), and DS (N = 139). **Results:** Results showed an increased reported level of gelotophobia in autistic individuals compared to individuals with WS and DS. This higher level seemed to be related to a higher level of seriousness and bad mood in autistic individuals.
Article 3: Humor styles in neurodevelopmental conditions and their relation to social, emotional, and behavioral strengths and difficulties.
Objectives: This study investigated humor styles (affiliative, self-enhancing, aggressive, self-defeating) in young individuals with ASD, WS, and DS. **Methods:** Questionnaires on humor styles, social difficulties, and mental health were distributed to parents of young verbal individuals (5–25 years old) with ASD (N = 31), WS (N = 34), and DS (N = 82). **Results:** Individuals with ASD engaged less in affiliative humor than individuals with DS, and more in self-defeating humor than individuals with DS and WS. These differences seemed to be partially related to increased externalizing conduct problems.
Article 4: Appreciation of slapstick humour and expressivity in relation to amusing stimuli in individuals with Williams syndrome.

Objectives: To investigate whether individuals with WS understand and appreciate simple humor and express it.

Methods: In an experimental task, short humorous and non-humorous film clips were shown to the individuals with WS (N = 8) and TD children (N = 9). They were asked to rate their level of amusement, and their smiles and laughs were coded and analyzed.

Results: Individuals with WS appreciated simple humor in much the same way as TD children did. They expressed more high-intensity laughter.

2 Articles

2.1 Article 1: How cognitive, social, and emotional profiles impact humor appreciation: sense of humor in autism spectrum disorder and Williams syndrome[7]

Abstract

Humor is a complex and multi-faceted phenomenon composed of a variety of cognitive, social, and emotional processes. This paper will discuss humor appreciation in individuals with autism spectrum disorder (ASD) and individuals with Williams syndrome (WS), a rare genetic disorder mainly characterized by intellectual disabilities, high social approach tendencies and high positive emotions. Drawing on research on the comprehension and appreciation of humor in individuals with ASD, this paper aims to better understand how the particular cognitive, social, and emotional profile of individuals with WS might affect their appreciation of humor and how such research could ultimately lead to a greater understanding of the nature of humor.

Keywords: autism spectrum disorder; humor; social motivation; theory of mind; Williams syndrome

[7] Reprint of: Treichel, N., Dukes, D., Barisnikov, K., & Samson, A. C. (2022). How cognitive, social, and emotional profiles impact humor appreciation: sense of humor in autism spectrum disorder and Williams syndrome. HUMOR, 35(1), 113–133. https://doi.org/10.1515/humor-2021-0038

1 Introduction

Humor is an important component of everyday life both for enhancing the quality of social interactions and for psychological well-being (Martin, 2007). While habitually associated with its potential to trigger positive emotions, humor can also elicit negative emotions when it is either intentionally aggressive or hostile (Martin et al., 2003), or when good-natured humor is wrongly perceived, presented at the wrong moment, or delivered in an inappropriate context (Samson & Gross, 2014). Humor also serves multiple functions in both intra- and interpersonal contexts related to regulating emotions individually (Samson & Gross, 2014) or socially (e.g., Horn et al. 2018). As such, humor involves cognitive, social, and emotional processes (Martin, 2007; Ruch, 2008): Here, the cognitive processes particularly involve the detection and resolution of incongruity (Ruch, 2008; Suls, 1972) and the interpretation of such as humorous; social processes refer both to the motivation to share laughter with others (Reddy et al., 2002) and abilities related to the Theory of Mind (ToM) (Howe, 2002; Samson, 2012); and the term emotional processes refers to the valenced experience of humor, which is usually positive (Ruch, 1993) but can also be negative (Ford, 2015), and which depends notably on traits that render the individual more or less susceptible to engaging in or responding to humor (Martin et al., 2003).

Given its complexity and all the different components involved, it is perhaps unsurprising that individuals are sensitive to different elements or types of humor, according to some aspects (e.g., cultural and social background) that could have influenced the development of their cognitive, social and emotional profiles. This is as true in typically developing individuals (Martin et al., 2003) as in those with atypical development. So far, humor research on atypical populations has mainly focused on autism spectrum disorder (ASD), revealing a range of difficulties with ToM (Baron-Cohen et al., 1985; Happé, 1993) and social communication, and reduced social motivation (Chevallier et al., 2012a), positive affect and empathic skills (Baron-Cohen, 2002; Lawson et al., 2004). Generally speaking, individuals with ASD also appear to be rather serious (Samson et al., 2013). As such, a general socio-emotional profile in ASD could seem, at first sight, inconsistent with the appreciation of humor.

In contrast, people with Williams syndrome (WS) seem to present with almost the opposite socio-emotional profile to people with ASD. This paper will address humor in individuals with WS, a rare genetic disorder (affecting about 1 in 7,500 live births, Strømme et al., 2002) involving intellectual disabilities although mainly characterized by their

hypersociability, high positive affect, pronounced empathic responses (Järvinen et al., 2013; Järvinen & Bellugi, 2013) and high social motivation and approach tendencies (Little et al., 2013). As such, the socio-emotional profile of individuals with WS seems to be much more consistent with the appreciation of humor. However, it is important to keep in mind that individuals with WS also typically show some difficulties in the social domain similar to those with ASD, and that their social profile is thus not absolutely and uniquely in opposition to ASD. This important point will be developed below.

The primary motivation for this paper is to outline the prototypical differences in socio-emotional profile in ASD and WS with a view to shedding light on their respective relation with humor. With this goal in mind, this paper provides a selective review of studies on humor comprehension and appreciation in ASD relevant for their comparison with WS. Combined with the few studies that exist on humor in WS, this selective review will serve as inspiration to make hypotheses about how humor is affected in individuals with WS. It seems that studying humor in these two populations is a very promising way of getting a better understanding of the very nature of humor, particularly its social aspect. What better than understanding extremes to be able to get the variability of a phenomenon? Moreover, as humor is an important part of our everyday life and in social communication, it is important to better understand the difficulties individuals with developmental disorders might have with humor in order to help enhance their social relationships and regulate their negative emotions, thus improving their well-being. In summary, this paper has two goals: To use humor research to reveal the relative strengths and weaknesses of clinical populations at extreme ends of the social profile, and, by doing so, to provide insight into the nature of humor itself (Samson, 2013).

The following sections will first address how humor is processed in terms of cognitive, social and emotional competencies. The distinction between these three components is widely used in the literature to provide a complete definition of humor (Martin, 2007; Ruch, 2008). While this distinction will continue to be used in this paper, it is important to acknowledge that, in reality, they are of course interrelated and often overlapping rather than separate independent components. For each component and their relative competences, the relevant literature about the humor profile of individuals with ASD will be reviewed and, based on this, hypotheses will be formulated about the humor profile of individuals with WS and how such further knowledge could contribute to a better understanding of the nature of humor.

2 Cognitive competencies in humor

The basis of any type of humor is for something to be perceived as being "funny" (Ruch 2008). It is widely held that, at its core, humor is about solving an incongruity – a mismatch between two conflicting events or pieces of information, or, in other words, between expectations based on previous knowledge and a surprising turn of events. In this sense, to understand a joke, a person not only has to possess knowledge about the normality (or expectation) that will be violated, but also has to have the ability to identify that there is an incongruity in relation to that normality (or expectation). However, it is equally important to be able to make sense of the incongruity, at least partially. This has been described as the "incongruity resolution process" (Suls, 1972). An example would be if we see a fish restaurant called, "The Plaice to be", this is humorous because 1) We know that 'the place to be' is normally written without an 'i'; 2) We notice that it is not written as it normally should; 3) We understand that the incongruity makes sense because it is a fish restaurant and "plaice" is a type of fish.

Attardo and Raskin (1991) pinpoint that the cognitive processes involved in humor are somewhat dependent on the type of humor itself, i.e., on how an incongruity should be resolved on the basis of specific cognitive rules (e.g., role exchange, exaggeration, or juxtaposition). Thus, some forms of humor are either more cognitively demanding than others or involve different cognitive capacities (Attardo & Raskin, 1991; Samson et al., 2008). As a consequence, there are important individual differences in the appreciation of particular types of humor depending on each individual's cognitive profile. As such, populations with different cognitive and intellectual disabilities are likely to appreciate some aspects of humor more or less than others with different relative strengths and disabilities. The understanding and appreciation of humor also involve executive functions, which are a set of cognitive skills involved in controlling, regulating, and adapting the immediate behavioral response to a specific situation based on mental models and future perspectives (Miyake et al., 2000). More specifically, working memory, shifting abilities and selective attention are directly involved in humor (Lyons & Fitzgerald, 2004).

The following sub-sections will address the cognitive specificities of humor appreciation in ASD and WS.

2.1 Cognitive competencies and humor in ASD

There is evidence that when individuals with ASD are able to understand the joke (i.e., for which they can solve the incongruity) they tend to appreciate it as much as typically developing (TD) individuals. Weiss et al. (2013), for example, showed that when presented with short nonverbal slapstick films in which the incongruity of the joke can be resolved independently of ToM requirements or language abilities (i.e., short scenes from the movies "Ice Age" and "Madagascar"), individuals with ASD enjoyed the humorous content as much as TD participants. However, several studies have shown that there are particular types of jokes that they typically find more difficult to understand. This, it has been suggested, is because they have a processing style of focusing on details rather than the "big picture" and that this makes it more difficult to extract a context-dependent meaning from particular information (Happé, 1997). This has notably been described in the "weak central coherence" hypothesis (Frith, 1989; Happé, 1997). Thus, instead of taking into account the general context of a humorous event, individuals with ASD seemed to focus at times on non-joke relevant details (see Lyons & Fitzgerald, 2004; Samson & Hegenloh, 2010). This is in line with the finding that individuals with ASD also show impairments in executive functioning. For example, two studies showed that individuals with ASD had more difficulty understanding cartoons and jokes because of impairments in cognitive flexibility (Emerich et al., 2003; Ozonoff & Miller, 1996). While they had to find the right ending – or, more colloquially, the 'punch line' – they tended to choose more straightforward endings or endings they considered humorous but that were not coherent with the joke. These results suggest that individuals with ASD might have difficulty in processing a combination of both surprise elements (i.e., a surprising turn of events) and coherent aspects of funny content. Such findings not only help reach a better understanding of ASD, they also stress the importance of executive functions in processing humor. Indeed, it underlines the ability to make sense of incongruity (i.e., to understand a joke) as necessary to get and appreciate a joke.

Since most of the studies have been carried out with high-functioning individuals with ASD, difficulties with some types of humor can be principally attributed to the socio-emotional characteristics of ASD itself, rather than to intellectual disability. As such, it would be important to either compare these results to individuals with ASD with intellectual

disabilities[8] or to individuals with intellectual disabilities of different origin (without ASD traits), to be better able to tease apart what is specific to ASD, and what can also be explained by cognitive impairments.

2.2 Cognitive competencies and humor in WS

Individuals with WS present cognitive impairments in the range of mild to moderate intellectual disability[9] (Korenberg et al., 2000). Despite high variability within the WS population (Porter & Coltheart, 2005), their cognitive profile is marked by an important dissociation between rather well-developed general language abilities compared to other types of intellectual disability (e.g., vocabulary, grammatical abilities, pragmatic language) and relatively spared verbal short-term memory (Mervis & John, 2010; Tager-Flusberg & Sullivan, 2000), but marked difficulties in visuo-spatial abilities (Heiz & Barisnikov, 2016), non-verbal reasoning and some aspects of executive function (Porter & Dodd, 2011; Rhodes et al., 2010). In terms of humor processing, and similarly to individuals with ASD, individuals with WS seem to have difficulties with working memory and selective attention. However, unlike individuals with ASD and other intellectual disabilities, notably Down syndrome (DS), their shifting abilities seem to be unimpaired (Costanzo et al., 2013; Menghini et al., 2010).

Generally speaking, individuals with intellectual disabilities seem to appreciate humor but show difficulties with certain types (in particular verbal humor) that require higher cognitive skills (for a review, see Chadwick & Platt, 2018). Thus, given the intellectual disability present in individuals with WS, difficulties in understanding and appreciating complex forms of humor are likely.

Indeed, one study showed that individuals with WS can have more difficulty understanding nonliteral language, namely sarcasm, metaphor and simile, than chronological age-matched controls (i.e., TD individuals who have the same age, based on the date of birth, Godbee & Porter, 2013). However, such differences were not apparent between WS and mental age-matched controls (i.e., TD individuals who have similar scores for cognitive ability tests). This suggests these difficulties could be related to intellectual disability. Furthermore,

[8] A recent study estimated that 33% of 8 years-old children diagnosed with ASD had an IQ ≤ 70 (Maenner et al. 2020).

[9] IQ scores range between about 40 and 80, with an average of 55 (Korenberg et al. 2000).

authors reported a strong correlation between non-literal language comprehension and general cognitive abilities in TD individuals, which was not the case for WS participants. These results indicate that the linguistic and cognitive systems on which non-literal language comprehension is based interact and integrate differently in WS than in TD individuals. Furthermore, according to the authors, difficulties in understanding sarcasm observed in individuals with WS might be due to the fact that sarcasm is more demanding on executive functions, such as cognitive flexibility and integration of context. The authors also suggest that it might be because of their hypersociability and bias toward positive affect that they tend toward a nicer or happier interpretation of sarcastic comments (Godbee & Porter, 2013). Importantly, these results suggest that the cognitive processes involved in solving the incongruity of a humorous content differ from one individual to the next. In other words, humor style is unlikely to be linked to a general measure of intelligence, such as IQ, since it is a complex cognitive phenomenon. Furthermore, these results indicate that the cognitive components of humor seem to be heterogenous: Different jokes necessitate different cognitive processes to be understood.

Overall, a better understanding of which forms of humor are spared and which are impaired in WS while considering their specific cognitive profile could help us better understand the variability of cognitive processes involved in the understanding and appreciation of humor in general. Considering their general cognitive impairments, individuals with WS would be expected to have difficulties with humor involving more complex incongruity resolution. Moreover, considering their relatively spared verbal skills but impaired visual-spatial competencies, it is likely that non-verbal humor would be more difficult to process than verbal jokes. Further research is necessary to more thoroughly investigate the impact of cognitive impairments in the appreciation and comprehension of different types of humor – for example, visual or verbal jokes involving different cognitive rules (Attardo & Raskin, 1991; Samson et al., 2008) – in individuals with WS.

3 Social competencies in humor

Humor is however not only about cognitive processing; it also involves socio-emotional processing. Indeed, humor is fundamentally social, as it oftentimes occurs in social interactions and serves social functions including relieving tensions, sustaining social control and ensuring social cohesion (Kuipers, 2008). Reddy et al. (2002) underlined how the presence of others and how the laugh of at least one other person facilitates laughter and elicits an increased appreciation of humorous content. Some jokes can also involve complex

socio-cognitive processes such as perspective taking and ToM. However, the relation between humor processing and ToM is not very clear. While some researchers support the mind-reading hypothesis (Howe, 2002) – that ToM is necessary for humor processing – more recent data does not support the idea of such a tight link between the two, and suggests, rather, that while some jokes require the ability to understand another person or character's mind in order to make sense, other, simpler forms of humor do not require such complex socio-cognitive abilities (Samson & Hegenloh, 2010; Samson, 2012). Considering the great differences in socio-emotional profiles of individuals with ASD and individuals with WS, it is here where the greatest differences in sense of humor is likely to be found and where most can be learned about humor itself. The following section will address social competencies, since the comparison of ASD and WS allows us both to draw on the existent literature and to hypothesize about the link between humor and social competencies.

3.1 Social competencies in humor in ASD

As described above, individuals with ASD tend to understand and produce specific types of humor without any difficulty, but they often do so with less intent of sharing it with others (Lyons & Fitzgerald, 2004). Thus, even when they show no cognitive impairments, individuals with ASD can still be said to have a particular humor profile, notably in relation to its social functions. This theory has indirect support from the fact that individuals with ASD also tend to show difficulties with empathy (Baron-Cohen, 2002; Lawson et al., 2004). One study showed that typically developing individuals with high empathy scores compared to those with low empathy scores seem to process humor differently, in the sense that, even though they do not show any better humor comprehension in general, they refer more often to the mental and emotional states of the characters in the joke when asked to explain the punchline (Samson, 2012). In line with these results, and given the fact that they tend to show less empathy, individuals with ASD seem to refer less frequently to (false) mental states of others when explaining cartoons, and they seem to understand and appreciate ToM cartoons less than TD individuals (Samson & Hegenloh, 2010). This is again consistent with studies that highlight difficulties with ToM in individuals with ASD (Baron-Cohen et al., 1985; Happé, 1993).

Some studies have compared humor comprehension and appreciation in individuals with ASD and individuals with DS, principally revealing differences in social competencies (Reddy et al., 2002; St. James & Tager-Flusberg, 1994). Based on parents' reports and analysis of videotaped interactions, Reddy et al. (2002) showed that children with ASD had

more difficulties than mental age-matched children with DS concerning the interpersonal relevance of laughter. Even though there was no difference in the frequency of laughter, children with ASD responded less to others' laughing by looking up or smiling and showed difficulties in sharing humorous moments. Furthermore, children with ASD almost did not engage in clowning, suggesting again less interest in sharing laughter. Indeed, they engaged in solitary laughs more often than children with DS.

Again then, research with DS seems to confirm that individuals with ASD tend to have a type of humor characterized by its link with social competencies. In sum, it seems that individuals with ASD use humor less in social interactions with the purpose of sharing with others compared to TD participants and individuals with DS. This could be explained by their diminished social motivation (Silva et al., 2017). Indeed, humor serves multiple social functions as described above, which can be seen as social rewards for the appreciation and production of humor. However, Kohls et al. (2013) have shown a general dysfunction in the reward system (social and non-social) in individuals with ASD, which may explain diminished social motivation and can be a cause of difficulties in social cognition in general (Chevallier et al., 2012a), and more specifically in relation to humor (Silva et al., 2017). Moreover, their difficulties with ToM impair their understanding of some types of jokes involving others false beliefs.

To summarize, research in ASD has stressed the social competencies involved in the appreciation of humor to understand specific types of jokes that require advanced socio-cognitive competencies, and also to have the motivation to share laughter or positive experiences with others. Future research could expand the understanding of the role of social motivation in humor appreciation and production. Considering that WS can be seen as being situated at the opposite extreme of a social continuum (although, see below), looking at their specificities concerning humor in the social domain will improve our knowledge of humor itself.

3.2 Social competencies in humor in WS

As noted earlier, the particular social profile of WS is characterized by high social approach tendencies, in particular toward strangers. They are also described as having a uniquely gregarious personality, high empathic responses and high positive affect (Järvinen et al., 2013). This hypersociability is often combined with inadequate social skills, which cause difficulties in sustaining friendships (Järvinen & Bellugi, 2013). However, there are also some overlaps between ASD and WS in the social domain: Individuals with WS show

difficulties in several social competencies, but not in social motivation (Fisher & Morin, 2017; Klein-Tasman et al., 2011). This social pattern seems to be very specific to WS: There seems to be somewhat of a contradiction between their high motivation to seek social interaction and their difficulties understanding and maintaining these social interactions. These results also suggest that individuals with ASD and those with WS cannot really be placed on opposite extremes of a social continuum (Fisher & Morin, 2017), as previously suggested (Jones et al., 2000), but rather, more prudently, on opposite extremes of a social motivation continuum.

There seems to be a dissociation in WS between the social and cognitive profiles in terms of mentalizing skills (which is the ability to make inferences about other people's thoughts and beliefs, in ToM, for example), although there is conflicting evidence. Initial research suggested that ToM (as well as language and face processing) was spared in WS, contrary to other cognitive abilities (Karmiloff-Smith et al., 1995). However, Tager-Flusberg and Sullivan (2000) nuanced these conclusions somewhat by distinguishing social-perceptual and social-cognitive components of ToM. The first component, which seems to be spared in WS, refers to the ability to make inferences about others' minds based on perceptual information such as facial expression, bodily behaviors or vocal prosody. The latter component, which seems to be typically impaired in WS, refers to complex cognitive abilities such as language, and is related to the understanding of false belief (Sullivan et al., 2003). Additionally, Porter et al. (2008) showed that ToM abilities in WS are below that which would be expected at their mental age when assessed using a non-verbal task, and therefore do not rely on verbal skills (which are known to be relatively preserved in WS). However, the researchers also showed that there were differences in the understanding of false belief between two cognitive subgroups (Porter & Coltheart, 2005), giving strength to the idea of a heterogeneity of WS cognitive profiles and mentalizing abilities. Thus, it is difficult to reach a clear conclusion about mentalizing abilities in WS, although it seems that their potential difficulties in this domain relate rather to the social-cognitive rather than the social-perceptual component. The conflicting evidence in the research concerning socio-cognitive ability could perhaps be linked to the great variability in cognitive ability present in WS.

Some types of humor are directly linked to mentalizing abilities and, given the tendency for individuals with WS to have difficulties with the social-cognitive component of ToM, it can be expected that they would have more difficulties processing such humor. Sullivan et al. (2003) compared adolescents in three groups, with either WS, Prader-Willi

syndrome (a genetic disorder also associated with mild to moderate intellectual disabilities), or intellectual disability of a non- specific origin, in their ability to differentiate between a lie and a joke. Participants were presented with four short stories that each ended with a false statement, two of which were lies and two of which were ironic jokes. The difference was based on the understanding of one character's second-order belief, which refers to what both characters know about each other's thoughts and knowledge. The results showed that almost all participants misclassified the jokes as lies and justified their answer with more realistic responses (referring to the actual state of affairs) and less second-order reasoning (referring to the knowledge states of the characters). Furthermore, individuals with WS gave significantly fewer second-order justifications and more realistic justifications than the two other groups. In short, it seems that, on average, adolescents with WS show great difficulty in making the link between others' minds and nonliteral language.

One recent study directly investigated the link between ToM and humor in WS (Krishan et al., 2017). The participants consisted of WS and DS participants, as well as a chronological age-matched control group for both clinical groups, and one mental age-matched control group for each clinical group. Each participant was shown a series of cartoons containing jokes that required them to infer a character's beliefs, desires or emotions. Participants were then asked to explain each joke. Individuals with WS and DS did not differ significantly in their level of comprehension of the jokes, nor with their respective mental age-matched TD peers. However, they showed poor humor comprehension in comparison to their chronological age- matched peers. This suggests that the difficulties these clinical groups seem to have with types of humor involving ToM are related to their intellectual disabilities and are not syndrome-specific. Furthermore, concerning the explanation of the jokes, the results showed that WS participants did not differ with both control groups in their use of mental state language, suggesting that humor comprehension was not related to ToM abilities. These results are consistent with studies suggesting that humor appreciation is not necessarily related to ToM (Samson, 2012).

Overall, previous studies show that individuals with WS have difficulties understanding jokes that involve mentalizing abilities. It would seem that, similarly to individuals with ASD, they might have more difficulty understanding and appreciating forms of humor that require high socio-cognitive abilities (Samson & Hegenloh, 2010). Future research should investigate the comprehension and appreciation of different types of humor in WS, including jokes requiring mentalizing abilities, in contrast to simple jokes (for an

example of how this could be done, see Samson et al., 2008). Such research would provide more knowledge on how humor is processed by individuals who have difficulties with ToM, which would help define the extent to which humor appreciation in general is related to ToM.

The social profile of individuals with WS is also characterized by high social approach, namely a tendency to seek out the social world and social interactions, particularly with strangers. Contrary to individuals with ASD, individuals with WS seem to have high social motivation as they show a particular interest in social stimuli (Barak & Feng, 2016), especially human faces (Riby & Hancock, 2009). Individuals with WS are often described as being "excessively friendly" (Järvinen et al., 2013). This hypersociability is likely to lead to paradoxical reactions to certain jokes, in the sense that, even if they do not understand the punch line (i.e., are not able to cognitively resolve the incongruity), they may nonetheless laugh. Thus, future research should try to disentangle the links between the level of comprehension (whether they understand the joke or not), the sociability of the occasion (who and how many people are present to share the joke) and the level of appreciation (how funny they thought the joke was) of different types of jokes. The correlation between level of comprehension and appreciation can be expected to be weaker in individuals with WS than in TD controls or individuals with ASD, particularly in social situations where the individuals' enjoyment could be influenced by others who did get the joke. Such an interaction would suggest that the implicit assumption that one should understand the incongruity of a joke might not be necessary for some individuals to still enjoy a shared humorous occasion. Future investigations should thus also contrast humor processing in a shared social context and in an individual, non-social context.

As stated before, studies on WS and ASD would be a great tool to expand our knowledge on humor in the social domain particularly. Indeed, ASD and WS can be seen as being at two extremes of a social motivation continuum. By studying ASD with intellectual disabilities in comparison to WS (thus with similar cognitive competencies), we would have a concrete way of looking at how the social profile influences humor perception and what it tells us about humor in general.

4 Emotional competencies in humor

Besides the cognitive and social competencies involved in humor processing, the appreciation of humor involves a subjective emotional experience that often has been referred to as amusement, mirth, or exhilaration (Ruch, 1993), but that can also involve mixed emotions (Kreibig et al., 2013) and even purely negative emotions (Ford, 2015). It also involves

an emotional response, including psychophysiological changes (Lackner et al., 2013; Shiota et al., 2011) as well as overt emotional expressions such as changes in the face, voice, or body – most typically smiling and laughing (Ruch, 2008).

Generally speaking, individuals differ in how strongly they react emotionally to humorous stimuli. For example, state and trait cheerfulness in contrast to seriousness and bad mood have been shown to be important factors impacting humor appreciation (Ruch et al., 1996). Individuals also seem to differ in relation to their preferred humor styles, e.g., if they prefer benevolent or rather aggressive, dark humor. For example, Martin et al. (2003) made the distinction between four different humor styles: Two positive (affiliative and self-enhancing) and two negative (aggressive and self-defeating)[10]. Affiliative humor is a non-hostile type of humor, which is positively correlated with social approach, positive emotions, and cheerfulness. Individuals who have high scores in affiliative humor appreciate telling jokes during social interactions. Self-enhancing humor designates the tendency to laugh at the incongruities of life. Individuals who have this sense of humor frequently use humor to regulate their negative emotions. Aggressive humor describes a negative humor style that is directed towards others. Finally, self-defeating humor consists in saying funny things about oneself at the expense of making oneself look ridiculous. Related to rather dark sides of humor, some individuals have more difficulty in dealing with mockery towards themselves, which can lead to gelotophobia, namely, the fear of being laughed at by others. At its extremes, gelotophobia can lead to paranoia and high social difficulties (Ruch & Proyer, 2008a). The following sub-sections will focus on the influence of the emotional profile of individuals with ASD on their relation towards humor and draw a few hypotheses about humor and individuals with WS, before pointing out the relevance to the conceptualization of humor.

4.1 Emotional competencies in humor in ASD

Studies concerning emotional responses have shown that individuals with ASD generally appreciate humor less than TD individuals, although, as described above, this depends strongly on the stimulus characteristics and the context (e.g., Samson & Hegenloh,

[10] There exists other conceptualizations of different humor styles, for example such as recently described by Ruch et al. (2018). However, we focus here on those questionnaires that have been used in the context of ASD research.

2010), and display, at times, facial expressions that are incoherent with their emotional experience (Weiss et al., 2013). In relation to individual differences that impact the susceptibility to (different types of) humor, a recent study (Samson et al., 2013) showed that individuals with ASD define themselves as having lower affiliative and self-enhancing humor than TD individuals (but no differences in aggressive and self-defeating humor). According to the authors, this suggests that individuals with ASD might be less social in their humor – which is in line with their social difficulties as described above – although it does not mean they engage more in negative forms of humor. Individuals with ASD also seem to be less cheerful, more serious, and more likely to be in a bad mood than TD individuals (Samson et al., 2013). Finally, individuals with ASD tend to have high scores of gelotophobia (i.e., the fear of being laughed at). Indeed, one study revealed that 45% had slight, marked or extreme levels of gelotophobia, compared to 6% of the TD comparison group (Samson et al., 2011). This is relevant for better understanding humor in ASD, since gelotophobes tend to enjoy humor less (Ruch & Proyer, 2008a). In general, these intra-individual differences are also important to understand why humor is more difficult to be processed and appreciated by individuals with ASD. Future studies should investigate more thoroughly the correlation between ASD's rather negative emotional profile and their subjective experience of humor, which would lead to a better conceptual mapping of different emotional profiles in relation to humor.

4.2 Emotional competencies in humor in WS

As mentioned earlier, individuals with WS tend to show a high level of empathy (Dykens & Rosner, 1999; Klein-Tasman & Mervis, 2003). These empathic skills originate from their high social approach tendencies (Little et al., 2013), characterized by their lack of shyness (no fear of strangers) and their tendency for direct eye contact (Järvinen et al., 2013). It is possible that their higher level of empathy might lead individuals with WS to be more sensitive to even mildly aggressive forms of humor directed at third parties. To explore the influence of the socio-emotional profile in individuals with WS, it would be informative to investigate their emotional responses to benevolent, mildly aggressive and hostile forms of humor while controlling for their comprehension (Ford, 2015; Kreibig et al., 2013). Given the research presented here, it can be hypothesized that individuals with WS would experience more negative emotions and show more aversion with mildly aggressive and hostile forms of humor than would TD controls or individuals with ASD.

Additionally, WS is characterized by a bias toward positive affect (Järvinen et al., 2013) and a rather cheerful personality (Tager-Flusberg & Sullivan, 2000) which suggests they may have a marked inclination to engage in humorous interaction. Indeed, based on their socio-emotional phenotype, individuals with WS would be expected to score high on cheerfulness, and low on seriousness and bad mood (Ruch et al., 1996), as opposed to individuals with ASD (Samson et al., 2013). Moreover, whereas individuals with ASD tend to have a low affiliative humor style, individuals with WS are likely to engage more in positive (particularly affiliative) humor, considering it is positively correlated to social approach tendencies, positive emotions, and cheerfulness (Martin et al., 2003). On the other hand, considering the high positive affect and empathy associated with WS, it can be postulated that such individuals are unlikely to engage in aggressive humor (Martin et al., 2003).

Whereas it has been argued here that the WS emotional phenotype would result in higher sensitivity to aggressive forms of humor, further research is required to ascertain whether individuals with WS would also be more sensitive in situations where they are the target of such humor and, as a consequence, experience gelotophobia (Ruch & Proyer, 2008a). This is an open question. One could hypothesize, for example, that because gelotophobia is related to social anxiety (Edwards et al., 2010), individuals with WS would not have a particular tendency to experience gelotophobia. However, given their probable aversion to aggressive humor, coupled with the high rates of bullying they experience (Fisher et al., 2017a), one could also argue that they would react negatively to being subjected to social mockery.

The relation between the emotional profile and humor appreciation in individuals with WS still has to be investigated. In the same sense that studies on ASD should investigate the extent to which their negative emotional profile leads to a lower appreciation of humor, further research on WS could confirm that a more positive emotional profile leads to a greater appreciation of humor. If this proved to be the case, it would suggest that even though cognitive, social and emotional components of humor are interrelated, they influence an individuals' appreciation of humor independently of one another. Moreover, getting knowledge about these two emotional profiles and their influence on how they experience humor would naturally help us draw a variety of emotional profiles and understand better individuals' differences in their experience of humor.

5 Conclusions

Humor is very important for social interaction and psychological well-being. It helps to establish social bonds, can be used to accentuate our role in a group, can help to regulate our own or others' emotions in difficult situations and can generally be considered as a trigger for positive emotions (Kuipers, 2008; Martin, 2007; Samson & Gross, 2014). It is a complex phenomenon involving cognitive, social, and emotional competencies. This paper aimed to gain a better understanding of how the particular cognitive, social, and emotional profiles of individuals with WS could affect their comprehension and appreciation of humor in contrast to individuals with ASD and of what these profiles and their comparison tell us about the nature of humor. It is important to keep in mind that these cognitive, social and emotional processes are interconnected and that studying them separately is a way to catch the most defined specificities of humor processing. However, it is equally important to study them together to better understand their separate and combined impact on humor.

The literature presented here shows how the executive functioning of individuals with ASD could explain why they have difficulties with some types of jokes (Lyons & Fitzgerald, 2004) but can appreciate simple forms of humor (Weiss et al., 2013), and how the cognitive impairments present in individuals with WS might prevent such individuals from understanding the incongruity of a joke. Given their tendency for hypersociability, it is possible that individuals with WS would laugh even if they do not get the joke – either for affiliative reasons or simply because they enjoy the laughter of others, for example, particularly when their high propensity for cheerfulness is taken into account. However, the reverse is observed in individuals with ASD, who have a tendency to engage less in shared social laughter (Reddy et al., 2002). Furthermore, particular difficulties in social perspective taking associated with WS (Tager-Flusberg & Sullivan, 2000) would be expected to impact the understanding of jokes based on false belief (i.e., ToM humor), as it is the case for individuals with ASD (Samson & Hegenloh, 2010). Finally, while individuals with ASD seem to appreciate and produce fewer positive forms of humor (Samson et al., 2013) and have a higher tendency to experience gelotophobia (Samson et al., 2011), the emotional profile of individuals with WS, characterized by unfiltered and high levels of empathy (Klein-Tasman & Mervis, 2003), suggests that they might not appreciate even mild forms of aggressive humor or find aggressive elements in harmless jokes.

This paper set out to improve understanding of the humor profiles in ASD and WS and to highlight the importance of taking into account population characteristics and

individual differences when considering humor. Specifically, focus was given to the contribution of specific cognitive, social and emotional profiles to the understanding and appreciation of different types of jokes. Further studies on humor in WS, perhaps in direct comparison to those already undertaken in ASD, would provide a better understanding of the nature of humor. While the assumptions and hypotheses made here already recommend and signal new directions of research to be taken, they suggest that definitions of humor should include more nuanced appreciations of cognitive, social and emotional profiles. While these remain necessarily speculative without empirical testing, this paper suggests such studies should evaluate the association between individual cognitive traits and the cognitive processes of humor appreciation by testing 1) the importance of higher cognitive competencies when it comes to understanding certain types of jokes with a more complex logical mechanism (e.g., sarcasm, irony, jokes involving ToM, etc.), 2) the variability of cognitive competencies involved in humor, and 3) the fact that humor is not necessarily linked to ToM. Such studies would also help draw a variety of social and emotional profiles of humor, based on two extremes of a socio-emotional continuum (mainly based on high differences in social motivation). Furthermore, such knowledge about which types of humor individuals with WS understand and appreciate could positively impact their social experiences and serve as inspiration for training programs to help individuals who have difficulties in social interaction by using humor as a tool to strengthen their social relations and deal with their negative emotions (about the effectiveness of such training in adolescents with ASD see e.g., Wu et al., 2016).

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2.2 Article 2: "Not in the mood": The fear of being laughed at is better predicted by humor temperament traits than diagnosis in neurodevelopmental conditions[11]

Abstract

Background: Research has shown that autistic individuals seem to be more prone to develop gelotophobia (i.e., the fear of being laughed at) than typically developing individuals. The goals of the present study were to discover whether the high levels of gelotophobia found in autism in previous studies were replicated here, to expand the research to Down syndrome (DS) and Williams syndrome (WS), and to assess the relation between individual differences and social impairments, affective predispositions, and humor temperament.

Methods: Questionnaires were distributed to parents of autistic individuals (N = 48), individuals with DS (N = 139), and individuals with WS (N = 43) aged between 5 and 25 years old.

Results: Autistic individuals were shown to frequently experience at least a slight level of gelotophobia (45%), compared to only 6% of individuals with DS and 7% of individuals with WS. Interestingly, humorless temperament traits (i.e., seriousness and bad mood) manifested as the strongest predictors of gelotophobia. This relation even transcended group differences.

Conclusion: The results confirm that gelotophobia seems to be particularly concerning for autistic individuals, whereas individuals with DS and WS seem to be more protected from developing such a fear. Moreover, it appears that gelotophobia seems to be more linked to high seriousness and irritability than diagnosis.

Keywords: Autism, Down syndrome, Williams syndrome, Gelotophobia, Humor temperament

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1 Introduction

Autism spectrum disorder (ASD) is characterized by difficulties in social interactions and communication, and repetitive restrictive behaviors (American Psychiatric Association, 2013). Autistic individuals also seem to have a particular socio-emotional profile, characterized by difficulties with Theory of Mind (Baron-Cohen et al., 1985), reduced social motivation (Chevallier et al., 2012b), a tendency to experience negative emotions more frequently (Samson et al., 2012), and a tendency to express positive affect less clearly (Joseph & Tager-Flusberg, 1997). Furthermore, autistic individuals have been described as having a particular relation to humor and laughter (Samson, 2013a; Treichel et al., 2022). Indeed, Samson et al. (2011) found that autistic individuals have a greater tendency to develop a fear of being laughed at than their typically developing peers. However, there is little research to date about this fear in other neurodevelopmental conditions, nor much insight about the link to individual characteristics.

The fear of being laughed at is called *gelotophobia* (from the ancient Greek *gelos*, which means “laughter” and *phobos*, which means “fear”), and is associated with the tendency to interpret others’ laughter as if it were aimed towards oneself, feeling ashamed and ridiculed as a consequence. Also present in the general population, gelotophobes consequently tend to be “agelotic”, meaning they are less likely to appreciate *any* types of laughter than non-gelotophobes (Titze, 2009). Gelotophobes experience a higher level of shame, anger and fear when exposed to ridicule than non-gelotophobes and they are more likely to experience negative emotions, even in the case of good-natured teasing (Platt, 2008). Furthermore, they are more likely to ascribe negative attributes (such as unpleasantness) to laughter (Ruch, Altfreder, et al., 2009), and seem to express less joyful smiles and more expressions of contempt than non-gelotophobic individuals as a response to laughter-eliciting videos (Ruch et al., 2015). Recent research has also revealed how gelotophobia affects the ability to develop close relationships: it is related to a lower likelihood of being in a romantic relationship, it is positively associated with attachment anxiety and avoidance (Brauer et al., 2020), as well as a greater jealousy (Brauer et al., 2021), and it is negatively associated with romantic relationship satisfaction (Brauer & Proyer, 2018).

The causes of gelotophobia appear to be numerous, and still need to be explored to be fully understood. Several authors highlight repeated and persisting experiences of being ridiculed and bullied as risk factors of developing a fear of being laughed at (Leader et al., 2018; Platt et al., 2009; Ruch et al., 2014). Personality traits, including high neuroticism,

emotionality, and Machiavellianism, as well as low extraversion, narcissism, and honesty-humility seem to be associated with the development of gelotophobia (Ruch et al., 2013; Torres-Marín et al., 2019; Tsai et al., 2018). Ruch, Beermann, et al. (2009) also highlighted the association with humor temperament. Unsurprisingly perhaps, gelotophobes appear to be rather serious, irritable and not very cheerful. Studies have also revealed how gelotophobia is related to mental health: It is positively correlated with the number of years spent in psychiatric care, with personality disorders, schizophrenic disorders (Forabosco et al., 2009), and in particular with Cluster A personality disorder (Weiss et al., 2012). Havranek et al. (2017) have also shown that gelotophobia is related to social anxiety disorder and avoidance personality disorder, even suggesting that gelotophobia be added as a diagnostic criterion for these two disorders. Furthermore, Brauer et al. (2022) examined the relation between gelotophobia and maladaptive personality traits (derived from the *Personality Inventory for DSM-5;* Krueger et al., 2012). Self- and other-reports revealed that gelotophobia correlated positively with Negative Affectivity, Detachment, and Psychoticism. To summarize, when considering individual factors, research has mainly highlighted the association with childhood experiences, personality traits, and mental health on the development of gelotophobia.

There is growing evidence of a high incidence of gelotophobia in autistic individuals without intellectual disability (ID), ranging between 40% and 45% of at least a 'slight' level of gelotophobia (Samson et al., 2011; Tsai et al., 2018; Wu et al., 2015). Leader et al. (2018) even found a higher rate in their study, with 87.4% of autistic individuals without ID experiencing gelotophobia. Tsai et al. (2018) further examined personality traits in relation to gelotophobia in autistic individuals, observing that a lower level of extraversion acted as a mediator to the higher level of gelotophobia in this group. Interestingly, their results revealed that lower levels of extraversion (rather than being on the autism spectrum) were related to higher levels of gelotophobia. This suggests that the higher fear of being laughed at in individuals with ASD is linked to some of the associated characteristics of ASD, rather than an integral part of the diagnosis itself. This finding is potentially very important when trying to understand the origins of gelotophobia in ASD. Furthermore, it is unclear whether this phenomenon is specific to ASD or whether it might concern neurodevelopmental conditions more generally. Indeed, to date, studies have only compared autistic individuals to TD individuals. A cross-diagnosis study is necessary to discern whether the origins of gelotophobia are specific to ASD or whether they are better explained by particular individual difference traits, for example.

However, so far, little is known about gelotophobia in neurodevelopmental conditions beyond ASD. With this in mind, the current study is the first to examine gelotophobia in other neurodevelopmental conditions, namely Down syndrome (DS) and Williams syndrome (WS). DS is a genetic disorder (affecting 1 in 800 live births, Lanphear & Castillo, 2007) characterized by non-verbal ID as well as specific language difficulties (Chapman & Hesketh, 2000). The associated behavioral skills are comparable to those of individuals with other neurodevelopmental conditions with ID, although individuals with DS are usually characterized as having fewer maladaptive behaviors than cognitively-matched individuals (Chapman & Hesketh, 2000). WS is a rare genetic disorder (1 in 20,000 live births, Morris et al., 1988) notably characterized by mild to moderate ID (Korenberg et al., 2000), maladaptive behaviors, a gregarious personality, and high positive affect (Järvinen et al., 2013). Individuals with DS or WS are generally described as having difficulties with Theory of Mind (Neitzel & Penke, 2021; Tager-Flusberg & Sullivan, 2000), with some social competences in the domains of social awareness, social cognition, social communication, and restrictive repetitive behaviors (Channell, 2020; Fisher & Morin, 2017), and experience similar rates and types of victimization than autistic individuals (Fisher et al., 2013), reporting increased incidences of being bullied (Fisher et al., 2017b; Jackson et al., 2014) and difficulties sustaining friendships (Iarocci et al., 2008; Järvinen et al., 2013).

Given how many of the characteristics that might influence the perception of others' laughter are shared with autistic individuals, it could be reasonably expected that individuals with DS and WS experience a similarly high level of gelotophobia. However, autistic individuals have been described as having temperament traits that are positively correlated with gelotophobia (Ruch, Beermann, et al., 2009): they have been reported to typically be rather serious, not very cheerful, and to have a tendency to be irritable (to be in a bad mood) (Samson et al., 2013). This contrasts with individuals with DS and WS who are generally described as being cheerful (Grieco et al., 2015; Tager-Flusberg & Sullivan, 2000), highly sociable and as having abnormally high social approach tendencies (Little et al., 2013; Porter et al., 2007). As such, individuals with DS and WS can be described as being at the opposite extreme of a social motivation scale to autistic individuals (Treichel et al., 2022). Cheerfulness and high social motivation might be expected to be protective factors against the development of a fear of being laughed at. One might therefore expect individuals with DS and WS to experience less gelotophobia than their autistic peers. In short, the question of whether gelotophobia is generally experienced by individuals with neurodevelopmental conditions, rather than being limited to autistic individuals, remains to be answered.

To summarize, the first goal of the present study was to discover whether the high levels of gelotophobia found in autism in previous studies were replicated here, and to expand the research to other neurodevelopmental conditions. The second goal was to gain a more in-depth understanding of the individual differences that could predict the existence and levels of gelotophobia. Traits were included that have been shown to be related to the appreciation of others' laughter, namely (1) social impairments, (2) predisposition towards positive and negative affect, and (3) one's humor temperament. With these two goals in mind, questionnaires were distributed to parents of young individuals with ASD, DS and WS. We hypothesized that autistic individuals experienced higher levels of gelotophobia than individuals with WS and DS, but we expected no difference between WS and DS. We also expected social impairments, predispositions towards negative and positive affect, and humor temperament to be correlated with gelotophobia. More specifically, we expected lower social motivation to be a significant predictor for a higher level of gelotophobia in ASD and that higher social motivation would act as a protective factor for DS and WS.

2 Methods

2.1 Participants

Parents of 48 autistic individuals, 139 individuals with DS and 43 individuals with WS between the ages of 5 and 25 years-old participated in a large survey-based online study. All participants answered the questionnaires in English. The majority of the children lived in England (83.48%, N = 192) or Scotland (8.70%, N = 20), while the remaining 9.13% (N = 21) were from various other countries. Almost all the parents (92.17%, N = 212) reported their child's ethnic origin as White (i.e., British, Welsh, Scottish, Northern Irish, Irish, or any other white background) (see supplementary section for full details).

2.2 Procedure

Parents were recruited through emails to participants from previous studies in the UK, to schools and associations, and through social media. The inclusion criterion was to be a parent of a child between 5 and 25 years-old on the autism spectrum, with DS or with WS. This study is a part of a larger survey-based study which includes 23 questionnaires on socio-emotional processing in neurodevelopmental conditions. Parents were paid £ 50 if they took part in the entire study. The study was approved by the local institutional review board of Unidistance Suisse.

2.3 Instruments

For this study, data from 4 questionnaires was analyzed to assess gelotophobia, social impairment, affective predispositions and humor temperament.

2.3.1 Gelotophobia

To assess gelotophobia, the 10 items assessing gelotophobia in the PhoPhiKat-30c (Proyer et al., 2012), a questionnaire assessing laughter and ridicule in 6–9 year-old children, were used. For the current study, the questions were translated and back-translated from German to English and then adapted for parents-report (e.g., "When my child hears others laughing, s/he thinks they are laughing at him/her"). Items were rated on a 4-point scale (1 = "strongly disagree", 2 = "moderately disagree", 3 = "moderately agree", and 4 = "strongly agree"). Ruch and Proyer (2008) defined cut-offs for the use of the GELOPH-15 in an adult population, which were also used in this study, in order to differentiate between people who experience 'slight' (mean score ≥ 2.5), 'marked' (≥ 3) or 'extreme' (≥ 3.5) gelotophobia and those who experience 'none' (< 2.5). Note that these cut-offs were defined from a 15-item self-administered questionnaire for adults. However, the same version has previously been shown to be reliable for studying children and adolescents: Führ (2010) tested the reliability of the self-reported Danish version of the GELOPH-15 on 11–16 years-old individuals, and found good psychometric properties. Tsai et al. (2018) also used the GELOPH-15 and its cut-offs to examine gelotophobia in Taiwanese adolescents between 14 and 18 years-old. In the present study though, a shorter version of 10 items built for children was used. Therefore, the cut-offs defined by Ruch and Proyer (2008) need to be interpreted cautiously in the present study. Additionally, the questionnaire was adapted for parental report which could also influence the evaluation of individuals' gelotophobia. However, previous research has shown that gelotophobia seems to be accurately perceived by others (e.g., self-other agreement correlations: r = 0.51 in Brauer et al., 2021; r = 0.49 and r = 0.53 in Brauer et al., 2022).

2.3.2 Social impairments

Social impairments, restricted interests, and repetitive behaviors, were assessed using the second edition of the Social Responsiveness Scale (SRS-2)[12] (Constantino &

[12] For the online administration of the SRS-2, we obtained the permission to adapt the format for specific, limited research use under license of the publisher, WPS (rights@wpspublish.com).

Gruber, 2012), which is a 65-item questionnaire intended for individuals on the autism spectrum or their parents. It is used to identify the severity of social impairments, and thus partially detect autistic symptoms. The items are divided into 5 subscales: social awareness (e.g., “His/her facial expressions send the wrong message to others about how he/she actually feels”), social cognition (e.g., “Takes things too literally, and because of that, he/she misinterprets the intended meaning of parts of conversation”), social communication (e.g., “Is able to communicate his/her feelings to others”), social motivation (e.g., “Would rather be alone than with others”), and restricted interests and repetitive behavior (e.g., “When under stress, engages in rigid or inflexible patterns of behavior that seem odd to people”). Two versions were used, according to the child’s age: a child version (age under 18) and an adult version (age equal or above 18). In both versions, items are similar but differentially formulated to correspond to the person’s age. The same 4-points scale was used in both versions (1 = “not true”, 2 = “sometimes true”, 3 = often true”, and 4 = “almost always true”).

A total raw score including all subscales was calculated, ranging from 65 to 260. Cutoffs have been defined as part of the SRS-2 scoresheet, based on the raw score, to determine the presence and severity of social impairments: none (lower than 68), mild (between 68 and 84), moderate (between 85 and 112), and severe (equal or higher than 113). A raw score was calculated for each subscale separately, ranging from 8 to 32 for social awareness, from 12 to 48 for social cognition and restricted repetitive behavior, from 22 to 88 for social communication and from 11 to 44 for social motivation. It is important to specify that in the present study, the scores of the SRS were used to compare general tendencies in social impairments, not to establish a diagnosis.

2.3.3 Affective predisposition

To measure predisposition (or mood) towards more positive or more negative affect, we used the PANAS (Watson et al., 1988). The parents were presented a series of 20 affective states and asked about the extent to which their child had felt each of them during the past few weeks. There are two sub-scales: positive affect (i.e., interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, active) and negative affect (i.e., distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, afraid). Each answer was scored on a 5-point scale (1 = “very slightly or not at all”, 2 = “a little”, 3 = “moderately”, 4 = “quite a bit”, and 5 = “extremely”). A score between 10 and 40 for both positive and negative affect separately was calculated.

2.3.4 Humor temperament

To measure humor temperament, the 30-item trait version (STCI-T30) of the State and Trait Cheerfulness Inventory (STCI) (Ruch et al., 1996) was used. This questionnaire measures the level of three components that are related to the temperament influencing an individual's experience towards humor: cheerfulness, seriousness and bad mood. Each of these components represents a subscale in the questionnaire, with 10 items for each. Cheerfulness (e.g., "Everyday life often gives my child the occasion to laugh") is seen as a facilitator towards a humorous temperament, whereas seriousness (e.g., One of my child's principles is: "first work, then play") and bad mood (e.g., "My child is often sullen") are traits that make individuals less inclined to respond positively to humorous stimuli. For parents of adults (more than 18 years-old), the STCI-T30 short trait form was used and adapted for parents-report. For parents of children under 18 years-old, the STCI-T30 peers-evaluation form was used, because the questions were more adapted for reporting children's experiences. The questions were rated on a 4-point scale (1 = "strongly disagree", 2 = "moderately disagree", 3 = moderately agree", and 4 = "strongly agree"). A score for each subscale was calculated, ranging from 10 to 40.

2.4 Data analysis

Analysis of the data consisted of three steps, (1) reliability analysis, (2) descriptive statistics of questionnaire scales, and (3) multiple linear regression of gelotophobia.

2.4.1 Reliability analysis

First, we evaluated the reliability of subscales (using the individual item scores) and total scales of the gelotophobia, SRS, PANAS, and STCI instruments by calculating Cronbach's alpha for the general sample, and for each diagnosis group. The cutoff for acceptable reliability was set at $\alpha_C = 0.7$. Scales that scored lower than this cutoff were further subjected to a leave-one-item-out analysis, to check if reliability could be improved by dropping one or more items.

2.4.2 Descriptive statistics

Second, we calculated descriptive statistics for all three diagnosis groups (ASD, DS, WS) on the relevant measures (demographical variables, gelotophobia, SRS subscales, PANAS subscales, STCI subscales; see Table 1). The descriptive analysis also tested for significant group differences, using ANOVA F-tests to test mean differences in continuous

variables, and a chi-square test to test for gender balance differences. In addition, we calculated and plotted Pearson correlations between all variables, using dummy variables (0–1 coded) to represent individual levels of the diagnosis and gender variables. For the autistic individuals, we additionally checked whether mean gelotophobia differed between participants with ID present (20), participants with ID absent (12), and participants with ID unknown (16).

Table 1

Demographic and trait differences between groups

	ASD (n = 48)	**DS (n = 139)**	**WS (n = 43)**				
Scale	**N**	**N**	**N**	***F* / χ**	***DF***	***P***	ε_p^2 / ϕ_c
Gender (F/M)	9/38	60/79	15/28	8.796	(2)	.0123	.20
	Mean (SE)	**Mean (SE)**	**Mean (SE)**				
Age (average in years)	10.3 (.80)	11.5 (.46)	11.7 (.83)	1.070	(2,226)	.3449	.00
Gelotophobia	2.4 (.09)	1.4 (.05)	1.5 (.09)	50.294	(2,225)	<.0001	.30
SRS – Social motivation	19.1 (.88)	11.2 (.52)	10.0 (.94)	34.390	(2,224)	<.0001	.23
SRS – Social awareness	13.0 (.57)	10.6 (.34)	11.5 (.61)	6.596	(2,224)	.0016	.05
SRS – Social cognition	20.7 (.90)	16.8 (.53)	20.5 (.96)	10.342	(2,224)	<.0001	.08
SRS – Social communication	37.2 (1.56)	24.0 (.93)	27.5 (1.67)	26.320	(2,224)	<.0001	.18
SRS – Restricted interests and repetitive behavior	22.0 (1.11)	16.0 (.66)	18.9 (1.19)	11.184	(2,224)	<.0001	.08
SRS – Total	111.9 (4.51)	78.6 (2.67)	88.5 (4.82)	20.244	(2.224)	<.0001	.15
PANAS – Positive affect	30.4 (.98)	33.8 (.58)	32.8 (1.04)	4.527	(2,225)	.0118	.03
PANAS – Negative affect	28.0 (1.07)	19.9 (.64)	23.7 (1.14)	21.772	(2,225)	<.0001	.15
STCI – Cheerfulness	26.6 (.61)	32.6 (.36)	32.0 (.64)	36.756	(2,223)	<.0001	.24
STCI – Seriousness	25.3 (.61)	16.9 (.36)	17.4 (.64)	74.141	(2,223)	<.0001	.39
STCI – Bad mood	27.7 (.76)	17.9 (.46)	18.5 (.81)	62.596	(2,223)	<.0001	.35

Note. ASD autism spectrum disorder, DS Down syndrome, WS Williams syndrome, SRS social responsiveness scale, PANAS positive and negative affect scale, STCI state trait cheerfulness inventory. One parent in the ASD group did not indicate their child's gender.

2.4.3 Multiple linear regression

Third, we conducted a stepwise multiple linear regression, with mean gelotophobia as the dependent variable, and three blocks of variables as independent variables (IVs), which were entered sequentially into the model. The first block consisted only of the diagnosis group variable, the second block added the demographical variables, and the third block

added the questionnaire variables (subscales of SRS, PANAS, and STCI). As such, four models in total were fitted, with the first consisting of the “empty” null model, containing only an intercept parameter, and the three subsequent models adding variable blocks incrementally. For each added block of IVs, we inspected the significance of effects with *F*-tests, and conducted pairwise contrasts between diagnosis groups using t-tests. As measures of effect, we computed partial ε^2 for *F*-tests, and standardized mean differences for t-tests.

At each stage of model building, we evaluated the goodness-of-fit of the model with R^2 and adjusted R^2. Furthermore, model di- agnostics were run to check violations of regression assumptions, including multicollinearity, outliers and influential cases, heteroscedastic residuals, and non-normal residuals. Multicollinearity (i.e., excessive correlation between IVs) was diagnosed by inspecting variance inflation factors (VIF) for effects, with effects exceeding a VIF of 10 removed from the final model (Kutner et al., 2005). Influential cases were diagnosed by the combined information of DFBETAs, DFFITs, covariance ratios, Cook’s distances, and the hat matrix diagonals (Kutner et al., 2005). Heteroscedasticity (i.e., non-constant variance of residuals) was diagnosed with the Breusch-Pagan test. Non-normally distributed residuals were diagnosed by visual inspection of quantile-quantile (QQ) plots of residual quantiles against quantiles expected under a normal distribution. In case of heteroscedasticity, we adjusted standard errors of inferential tests using the heteroscedasticity-corrected HC3 estimator (Long & Ervin, 2000). In case of non-normality, we calculated as a back-up non-parametric p-values from an equivalent permutation regression model, using the Freedman-Lane method for permutation, and 5000 random permutations to obtain permutation p-values (Frossard & Renaud, 2019).

All inferential tests were conducted at a reduced significance level of $\alpha = 0.005$. We chose this as a general correction for reducing the likelihood of finding false positive results, in accordance with recent proposals for improving the reproducibility of findings (Benjamin et al., 2018).

2.4.4 Software

All analyses were run using the R statistical software, version 4.0.3 (R Core Team, 2020), using packages "car" (J. Fox & Weisberg, 2019), for general Type II ANOVA, heteroscedasticity-corrected ANOVA, and variance inflation factors, "psych" (Revelle, 2020), for reliability analysis with Cronbach’s alpha, "corrplot" (Wei & Simko, 2017), for visualizing correlations, "permuco" (Frossard & Renaud, 2019), for permutation regression, effect size

(Ben-Shachar et al., 2020), for effect sizes, "emmeans" (Lenth, 2020), for model-based contrasts, "lmtest" (Zeileis & Hothorn, 2002), for heteroscedasticity-corrected pairwise contrasts.

3 Results

3.1 Reliability analysis

Reliability analyses with Cronbach's alpha revealed generally good reliability for all scales and subscales, and for all groups, with alpha values exceeding 0.7 and sometimes approaching 1.00 (see supplementary material). Total scales were more reliable than subscales. SRS – Social awareness had the lowest overall reliability, although not much below 0.7. An inspection for this subscale with a leave-one-item-out analysis did not identify any individual item that could be dropped, such that the desired reliability could be reached. The ASD group revealed some slight instabilities compared to the other two groups, with reduced reliability for SRS – Social awareness, STCI – Cheerfulness, and STCI – Bad mood.

3.2 Descriptive statistics

As revealed in Table 1, autistic individuals, individuals with DS, and individuals with WS did not differ regarding their age. The groups differed regarding gender, there were more male autistic individuals (see Table 1).

Parents were asked to estimate their child's ID (i.e., learning disabilities) level on a 3-point scale: 1) mild to moderate, 2) severe, or 3) none. The distribution of the general ID estimation per group can be seen in Table 2. As expected, all individuals with DS and WS for whom such data was reported showed at least mild to moderate ID, whereas the group with autistic individuals was more cognitively diverse. In addition, the severity of autistic symptoms related to social impairments was measured with the total score of the Social Responsiveness Scale (SRS-2) (Constantino & Gruber, 2012). All but one of the autistic children showed clinically significant social impairments. Individuals with DS and WS showed more diverse levels of social impairments. The distribution of the severity of social impairments in all groups can be found in Table 2.

The percentages of individuals who experience gelotophobia differed in each group: (see Fig. 1): 60% of the autistic individuals displayed at least a slight level of gelotophobia: 37.5% slight (N = 18), 20.8% marked (N = 10) and 2.1% extreme (N = 1). 39.6% (N = 19) showed no particular fear of being laughed at. A great majority of the DS individuals, 94.3%

(N = 131) experienced no such fear, only 6% experienced gelotophobia: 3.6% (N = 5) slight, 0.7% (N = 1) marked and 1.4% (N = 2) extreme. Individuals with WS displayed almost identical results to individuals with DS: 93% experience no fear (N = 40), 4.8% slight (N = 2), 2.3% extreme (N = 1) and no participant displayed a marked fear.

Table 2

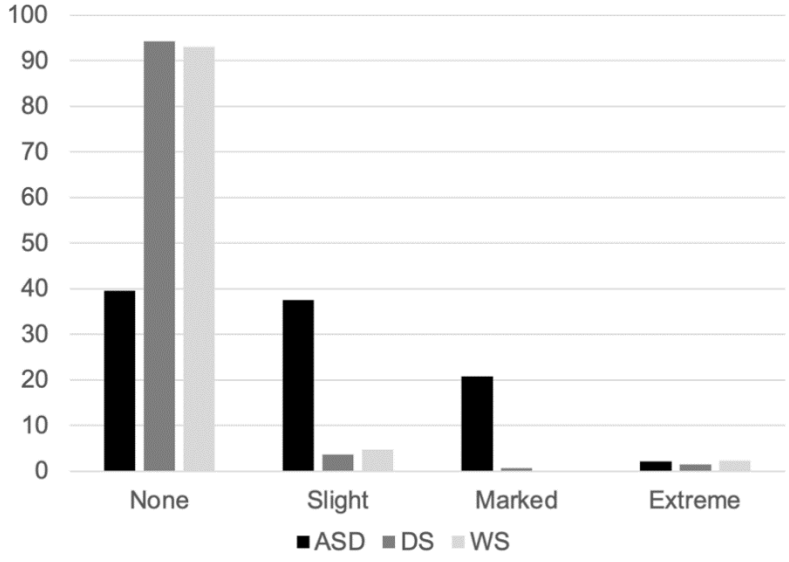
Description of the children's characteristics

Group	ID				SRS (severity of autistic symptoms)			
(total n)	None	Mild to moderate	Severe	Answer missing	None	Mild	Moderate	Severe
ASD (n = 48)	25% (n = 12)	35.4% (n = 17)	6.3% (n = 3)	33.3% (n = 16)	2.08% (n = 1)	6.25% (n = 3)	50% (n = 24)	41.7% (n= 20)
DS (n = 139)	0% (n = 0)	43.9% (n = 61)	25.2% (n = 35)	30.9% (n = 43)	46.8% (n = 65)	12.9% (n = 18)	22.3% (n = 31)	18% (n = 25)
WS (n = 43)	0% (n = 0)	60.5% (n = 26)	18.6% (n = 8)	20.9% (n = 9)	30.2% (n = 13)	16.3% (n = 7)	30.2% (n = 13)	23.3% (n = 10)

Note. ID intellectual disabilities, SRS social responsiveness scale, ASD autism spectrum disorder, DS Down syndrome, WS Williams syndrome

Figure 1

Percentage of gelotophobia per group



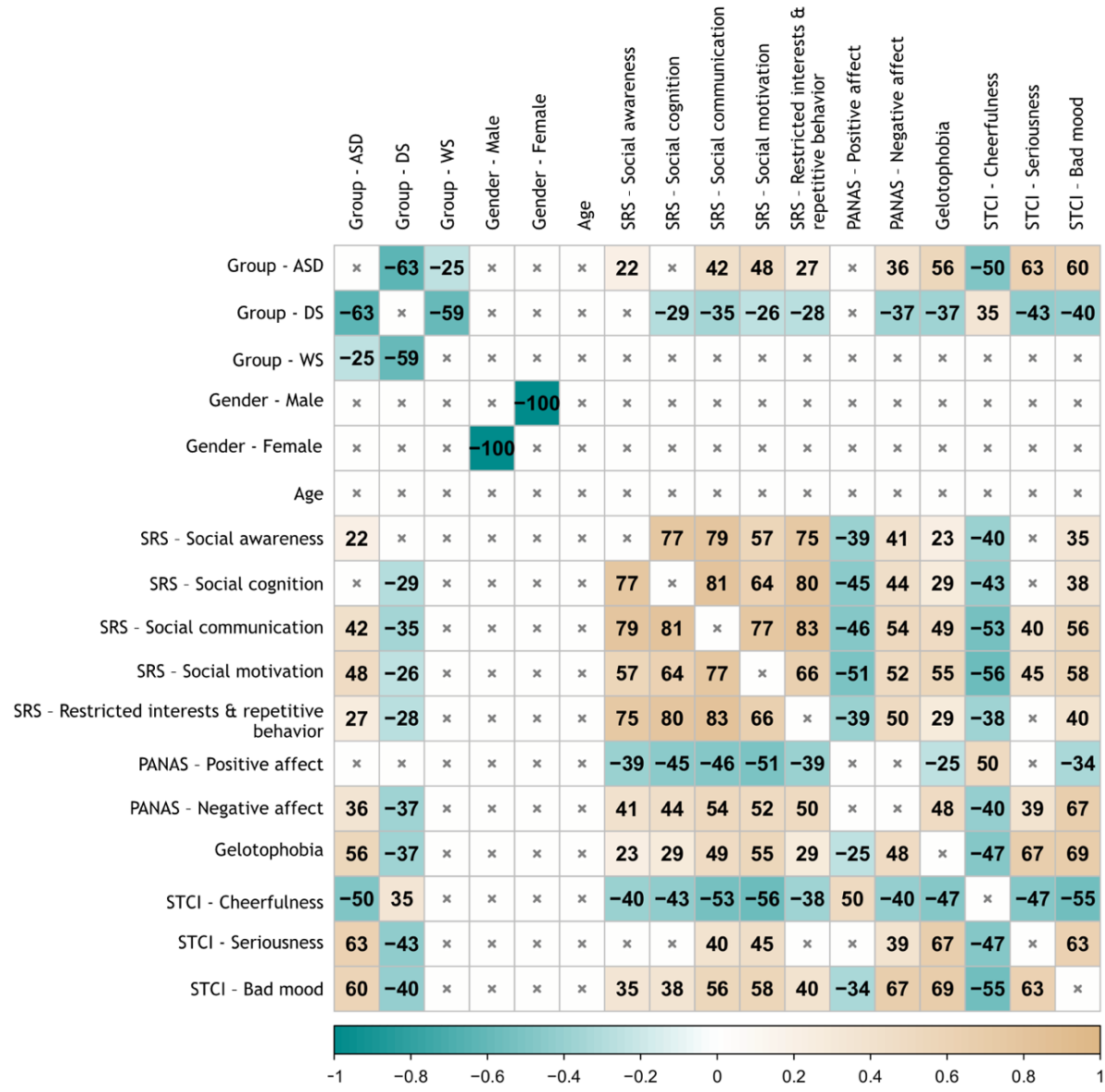
Note: Percentages of participants in each group (ASD autism spectrum disorder, DS Down syndrome, WS Williams syndrome) who have gelotophobia according to the following cut-offs: none < 2.5; slight ≥ 2.5; marked ≥ 3; extreme ≥ 3.5.

The three groups differed significantly on all measures (gelotophobia, SRS subscales, PANAS subscales, STCI subscales), at $\alpha = 0.005$, with the exception of the PANAS-Positive affect subscale, age, and gender (Table 1). Within the autistic individuals, there were no significant differences in mean gelotophobia between different levels of ID (present, absent, unknown), $F(2,45) = 1.256$, $p = .2947$, $\varepsilon_p^2 = .01$.

Correlation analysis using Pearson correlation (Fig. 2) revealed that being on the autistic spectrum was significantly positively correlated with all questionnaires' (sub)scales, except PANAS – Positive affect (not significant), and STCI – Cheerfulness (negative). The reverse pattern was observed for the DS group, for whom group membership was negatively correlated with all the tested individual characteristics, except for PANAS – Positive affect and STCI – Cheerfulness (positive). The diagnosis of WS was not significantly correlated to any questionnaire (sub)scale. Age and gender were also not significantly correlated to questionnaire (sub)scales, with the exception of a negative correlation between age and PANAS – Positive affect. SRS subscales were significantly intercorrelated, as were STCI subscales. The two PANAS subscales were not significantly correlated.

Figure 2

Correlations scores between all demographic variables and subscales of each questionnaire.



Note: ASD autism spectrum disorder, DS Down syndrome, WS Williams syndrome, SRS social responsiveness scale, PANAS positive and negative affect scale, STCI state trait cheerfulness inventory

3.3 Multiple linear regression

Results of the stepwise regression procedure are summarized in Table 3. Group differences in mean gelotophobia were significant (Model 1). Pairwise contrasts revealed that mean gelotophobia was significantly higher for autistic individuals (μ_{ASD} = 2.40) versus individuals with DS (μ_{DS} = 1.40), $t(225) = 9.825$, $p < .0001$, $\beta_z = 1.38$, and versus individuals with WS (μ_{WS} = 2.40), $t(225) = 7.437$, $p < .0001$, $\beta_z = 1.30$. Mean gelotophobia did not differ significantly between individuals with DS and WS, $t(225) = -.494$, $p = .62$, $\beta_z = -.07$. These differences remained significant after controlling for demographical variables (Model 2), but disappeared after additionally controlling for questionnaire variables (Model 3). In Model 3, no pairwise contrasts between diagnosis groups reached significance (all $p > .05$).

Model 3 explained about 60% of the observed variance in gelotophobia, $R^2_{adj} = .595$. Only effects of STCI – Seriousness and STCI – Bad mood were significant. Respectively, higher STCI – Seriousness and higher STCI – Bad mood predicted higher mean gelotophobia. Effects of other individual characteristics were not found to be significant in Model 3. However, there were trend effects for SRS – Social communication and age. Respectively, higher SRS – Social communication and higher age predicted higher mean gelotophobia.

Model diagnostics did not reveal any important violations of assumptions. No issues with multicollinearity, influential cases, or non-normal residuals were detected. Regarding heteroscedasticity, the Breusch-Pagan test was significant for Model 3, $\chi(14) = 43.397$, $p < .0001$, suggesting evidence against constant variance of residuals. However, a heteroscedasticity-corrected ANOVA using the HC3 estimator resulted in identical conclusions regarding the effects of diagnosis group and questionnaires. Finally, permutation regression p-values were calculated for all models, as a back-up against violations of non-normality, but these differed little from the parametric p-values (see Table 3).

Table 3

Results of the stepwise linear regression analysis.

Effect	Beta	*F*	DF	*P*	P_{perm}	P_{HC3}	ε_p^2
Model 1 - Group model (R^2 = 0.309)							
Diagnosis	1.38	50.294	(2,225)	<.0001	.0002	-	.30
Model 2 - Demographics model (R^2 = 0.337)							
Diagnosis	1.40	50.71	(2,222)	<.0001	.0002	-	.31
Age	.18	11.175	(1,222)	.0009	.0010	-	.04
Gender	.05	.226	(1,222)	.6351	.6356	-	.00
Model 3 - Traits model (R^2 = 0.620)							
Diagnosis	.10	.211	(2,208)	.8101	.8008	.9008	.00
Age	.14	8.043	(1,208)	.0050	.0064	.0072	.03
Gender	.11	1.501	(1,208)	.2209	.2170	.2783	.00
SRS – Social awareness	-.09	1.162	(1,208)	.2822	.2846	.4014	.00
SRS – Social cognition	-.02	.029	(1,208)	.8652	.8708	.8881	.00
SRS – Social communication	.23	4.372	(1,208)	.0378	.0352	.0323	.02
SRS – Social motivation	.15	3.608	(1,208)	.0589	.0592	.1299	.01
SRS – Restricted interests & repetitive behavior	-.17	3.718	(1,208)	.0552	.0584	.0401	.01
PANAS – Positive affect	.04	.432	(1,208)	.5118	.5226	.5269	.00
PANAS – Negative affect	.06	.742	(1,208)	.3899	.3878	.4124	.00
STCI - Cheerfulness	.00	.003	(1,208)	.9582	.9646	.9671	.00
STCI - Seriousness	.26	15.946	(1,208)	<.0001	.0006	<.0001	.07
STCI – Bad mood	.37	22.367	(1,208)	<.0001	.0002	<.0001	.09

Note. Linear regression analyses with three variable blocks added incrementally, Group, Group+Demographics, and Group+Demographics+Traits. ASD autism spectrum disorder, DS Down syndrome, WS Williams syndrome, SRS social responsiveness scale, PANAS positive and negative affect scale, STCI state trait cheerfulness inventory, P_{perm} permutation p-value, P_{HC3} Heteroscedasticity-corrected p-value.

Results of stepwise modelling suggested that gelotophobia was predicted by high scores on STCI – Seriousness and STCI – Bad mood traits, rather than by a specific categorical diagnosis (e.g., ASD). To test this result further, we conducted two follow-up analyses, **(a)** checking the association between individual questionnaires and gelotophobia, and **(b)** testing the group × STCI – Seriousness and group × STCI – Bad mood interactions. For analysis (a), we added the SRS, PANAS, and STCI variables separately to the model containing diagnosis group and demographics effects (Model 2), in all possible combinations (SRS-alone, PANAS-alone, STCI-alone, SRS-PANAS, SRS-STCI, PANAS-STCI SRS-PANAS-STCI). This analysis confirmed that group differences in mean gelotophobia only disappeared in the presence of the STCI variables, and not in the presence (or combination)

of SRS and PANAS variables. The effect of age was reduced somewhat by the presence of SRS variables, while highly significant effects of PANAS – Negative affect, SRS – Social communication and SRS – Social motivation disappeared in the presence of the STCI variables. For analysis (b), no evidence was found that the effects of STCI – Seriousness and STCI – Bad mood were modified by diagnosis group, with $F(2,204) = 2.046$, $p = .1318$, $\varepsilon_p^2 = .01$ for group × STCI-SE, and $F(2,204) = 0.567$, $p = .5682$, $\varepsilon_p^2 = 0.00$ for group × STCI – Bad mood. This suggested that the association between these two STCI scales and gelotophobia generalized across the three diagnosis groups.

4 Discussion

The present study had three main goals: (1) determine whether the high levels of gelotophobia found in autism in previous studies were replicated here (2) expand research on other neurodevelopmental conditions, i.e., DS and WS and (3) examine which individual differences (traits and moods) might be associated with potential group differences in gelotophobia amongst autistic individuals, individuals with DS and individuals with WS.

Consistent with the existing literature suggesting that autistic individuals experience more gelotophobia than other groups, 60% of autistic children in the current study were reported as having at least a slight level of gelotophobia (which is a higher rate than rates previously reported in the literature), in comparison to only 7% of children with WS and 6% with DS. Results also indicated a positive correlation between autism and the level of gelotophobia, meaning that individuals have a greater chance of experiencing gelotophobia if they are on the autism spectrum. Indeed, given the results, individuals with DS and individuals with WS seem to be rather protected from developing a fear of being laughed at. Additionally, a significant difference in the level of gelotophobia between autistic individuals and both individuals with WS or DS was revealed, but no difference appeared between DS and WS. These results confirmed our first hypothesis, i.e., that young autistic individuals (with or without ID) experience a higher level of gelotophobia than individuals with WS and DS, and that there would be no difference between WS and DS groups.

To answer the second hypotheses a regression analysis explored the potential predictors of gelotophobia that might be associated with these group differences. The second regression model added the demographic information of age and gender and showed that age was also a strong predictor of gelotophobia: in other words, the older the individual, the more gelotophobic they are likely to be. It is however important to keep in mind that a

majority of the sample of the present study lies within the age-range that seems to be most sensitive to gelotophobia (before 20 years-old, according to Platt et al., 2010). The significant relation between age and gelotophobia in the present study shows that for individuals with neurodevelopmental conditions, gelotophobia seems to manifest itself more strongly during adolescence and the beginning of adulthood rather than during childhood.

We also investigated the association between individual differences and the level of gelotophobia. The results showed that gelotophobia increased as autistic symptoms became more severe, and also increased with a tendency to experience more negative and less positive affect. It also correlated negatively with cheerfulness, and positively with seriousness and bad mood, consistent with (Ruch et al., 2009a). Other studies have shown that several processes are involved in the appreciation and understanding of humor and laughter (Ruch, 2008), and that moods and traits tendencies might drive individuals to be more or less inclined to be offended by others' laughter. The next step was then to investigate the association of such trait and mood characteristics with the observed groups differences. Indeed, we expected the higher social impairments commonly associated with autism, in particular in the social motivation subscale (Porter et al., 2007; Treichel et al., 2022), to be related to group differences.

The results showed a trend effect of social communication, as well as restricted interests and repetitive behaviors (subscales from the SRS), suggesting that higher difficulties in these social domains are associated with a higher fear of being laughed at. Surprisingly, there was no effect of social motivation on gelotophobia, contrary to expectations. This means that the inclination to engage with people is not a protective factor of the fear of being laughed at, and that low social motivation is not a risk factor for gelotophobia. The variables that had the strongest association with gelotophobia were, in fact, seriousness and bad mood. Both share similarities in being negatively correlated with a humorous temperament. They differ however on the fact that seriousness refers to a frame of mind (a way to approach everyday life's stimuli in a serious way, e.g., to prefer activities with rational and concrete goals), whereas bad mood, or irritability, is rather an affective state composed of bad mood, sadness, and ill-humoredness (Ruch et al., 1996). In short, the more a person has a tendency to approach life in a serious manner or to be in a bad mood, or, in other words, the more a person will have a non-humorous temperament, the more they tend to experience others' laughter negatively and as directed towards themselves. Importantly, the current analysis also showed that once these variables were added to the regression model, the group effect

disappeared, meaning that the diagnosis of ASD was no longer a significant predictor for gelotophobia. In other words, the degree to which an individual scores highly on seriousness and bad mood predicts gelotophobia over and above an overall developmental disability classification such as ASD, WS or DS (or their associated social impairments). These results still relate to group differences though as autistic individuals scored significantly higher in seriousness and bad mood than individuals with WS and DS. In other words, if autistic individuals have such a fear of being laughed at, it may be because they have a temperament less consistent with the appreciation of laughter and humor (Samson et al., 2013). Therefore, autistic individuals are at greater risk to develop gelotophobia linked to low extraversion (Tsai et al., 2018) and, as the present study reveals, high seriousness and irritability.

To our knowledge, this is the first study to explore gelotophobia in DS and WS. The present results showed that only 6% of young individuals with DS and 7% of young individuals with WS experience at least a slight level of gelotophobia, which is very close to the 6% of TD adults found in a previous study (Samson et al., 2011), although less than that found in self-reports from TD children and adolescents (26.3% in Tsai et al., 2018; 28.8% in Proyer et al., 2012). This difference might notably be explained by the fact that the questionnaires in this study were answered by adults for their children which might impact how well or frequently the phenomenon is perceived. Previous studies have shown the consistency of peer-reported gelotophobia in adults by adult-informants (Brauer et al., 2021, 2022), but this study is, to our knowledge, the first to use parent-reports for children and adolescents. It has been reported that adults experience less gelotophobia than children and adolescents (Platt et al., 2010). As such, they might reliably report gelotophobia observed in other adults, but perceive it less strongly than children and adolescents would. Therefore, although there seems to be no particular reason to question the validity of our results, future studies should include both self-report and parent-report in order to compare them. Furthermore, individuals with WS and DS even show mean levels of gelotophobia which are lower than the scores reported for TD individuals in the literature: e.g., 2.42 in 6–9 years-old (Proyer et al., 2012), 2.3 in 11–14 years-old (Tsai et al., 2018), and 1.76 in adults (Samson et al., 2011). Moreover, in the present study, individuals with DS and WS showed a high level of cheerfulness, and a low level of seriousness and bad mood. This is consistent with the general prototypical socio-emotional profile of iddividuals with DS (Grieco et al., 2015) and those with WS (Järvinen et al., 2013), which have both been described as being rather cheerful (Grieco et al., 2015; Tager-Flusberg & Sullivan, 2000). As such, individuals with DS and WS might be protected from developing gelotophobia due to their tendency to

appreciate humor and laughter which allows them to interpret others' laughter rather positively, or at least not negatively. The experience of others' laughter thus seems to be rather positive for individuals with DS and WS and not a source of social anxiety as can be the case for autistic individuals. Indeed, this positive temperament towards humor may even partly explain why individuals with DS and WS appear to have a lower tendency to develop social anxieties, compared to autistic individuals (Evans et al., 2005; Rodgers et al., 2012), a potentially important hypothesis concerning their wellbeing.

4.1 Limitations and future studies

Given that this study has been conducted anonymously online and that we wanted to keep the study simple for parents (with just one link to follow), we were unable to confirm the diagnosis of the children. However, care was taken during recruitment by sending emails only to special education schools and associations and by selecting specific social media pages on which the research was advertised. A second limitation also relates to the online design of this study which made it difficult to assess general cognitive skills. To address this issue, we asked parents whether their child had mild to moderate, severe or no learning disabilities. The parents' reports suggested the group is cognitively diverse and there were no differences in gelotophobia between the participants whether they were reported to have ID or not.

We would like to mention that our findings should ideally be replicated including a higher number of participants, especially for autistic individuals, as gelotophobia was most prevalent in that group. Future research should also examine gelotophobia in neurodevelopmental conditions in a longitudinal study to capture any developmental aspect. Indeed, while the current study focused on the period of life where gelotophobia seems to be at its most prevalent (i.e., childhood and adolescence), it would be important to examine such processes later in the lifespan. Finally, gelotophobia in ASD needs to be examined in more detail, notably by investigating whether all three components of gelotophobia described by Platt et al. (2012), namely "*paranoid sensitivity to anticipated ridicule*", "*disproportionate negative response to being laughed at*", and "*defensive coping with derision (control, withdrawal, internalizing)*", equally contribute to a higher level of gelotophobia in ASD, or whether one factor in particular might contribute to a better understanding of the phenomenon.

5 Conclusion

Autistic individuals have repeatedly been shown to experience gelotophobia at a higher rate than TD individuals (Leader et al., 2018; Samson et al., 2011; Tsai et al., 2018; Wu et al., 2015) and, it can now be revealed, than individuals with WS or DS. The present study showed that this particularity of autistic individuals was related to specific temperament traits which seem to render them less inclined to positively appreciate humor and laughter. Indeed, they appear to be more serious and more irritable than individuals with DS or WS, or when compared to TD individuals (Samson et al., 2013). Moreover, seriousness and bad mood appear to be important predictors of gelotophobia, transcending even groups differences, suggesting that high gelotophobia is better predicted by these temperamental traits than by the diagnosis itself. Future studies should examine the cognitive, social and emotional origins of these particular humor temperaments in neurodevelopmental conditions to gain a better understanding of the potential risk and protective factors of developing a fear of being laughed at. Future research should also look into the different levels of intensity of both autistic traits (regardless of the diagnosis) and gelotophobia to better understand whether the former might be associated with the latter also in a TD population. With such knowledge, prevention programs and interventions potentially targeting a playful attitude (by improving cheerfulness and decreasing seriousness in humorous situations) and improved emotion regulation skills to decrease negative and increase positive emotions and moods could be designed to prevent the development of gelotophobia in prone individuals.

What this paper adds?

Gelotophobia, i.e., the fear of being laughed at, implies interpreting and experiencing any laughter (even benevolent) in a negative manner, which can be a real impairment in everyday social interactions. Since previous studies have shown particularly high levels of gelotophobia in autistic individuals, it is important to better understand the origins of such a fear. This study replicates previous findings, showing that autistic individuals seem to be particularly prone to develop gelotophobia. Additionally, it shows for the first time that individuals with Down syndrome and individuals with Williams syndrome are not at risk of developing such a fear of being laughed at, compared to autistic individuals. Our findings also highlight that among several individual difference characteristics, the temperament traits of seriousness and bad mood seem to predict high levels of gelotophobia in autistic individuals, more than the diagnosis itself. As such, it seems to be because autistic individuals tend to be rather serious and irritable that they tend to develop a fear of being laughed at, whereas individuals with Down syndrome and Williams syndrome show no such tendency.

Data Availability

Data is available here: https://osf.io/qxwgj/

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ridd.2023.104513.

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2.3 Article 3: Humor styles in neurodevelopmental conditions and their relation to social, emotional, and behavioral strengths and difficulties[13]

Abstract

When it is positive, humor can improve psychological well-being and social interactions, but when it is negative, it can also be harmful. As such, it is important to better understand what type of humor individuals with different neurodevelopmental conditions tend to use. This study investigated the use of four different humor styles, namely affiliative, self-enhancing (both positive), aggressive, and self-defeating (both negative) humor, in individuals with autism (ASD), Down syndrome (DS), and Williams syndrome (WS). Moreover, it investigates the relation of potential differences in humor styles with social, emotional, and behavioral difficulties and strengths. Questionnaires assessing humor styles, social difficulties, and mental health have been distributed to parents of young individuals (5-25 years old) with ASD (N = 31), DS (N = 82), or WS (N = 34). The results revealed that autistic individuals produce more self-defeating humor than both individuals with DS and WS, which seems to be related to increased externalizing conduct problems. These results are discussed in relation to how they contribute to a better understanding of humor in neurodevelopmental conditions.

Keywords: Humor styles, Autism Spectrum Disorder, Williams syndrome, Down syndrome, mental health, social cognition

[13] Reprint of: Treichel N., (2023). Humor styles in neurodevelopmental conditions and their relation to social, emotional, and behavioral strengths and difficulties. *Manuscript submitted for publication to Swiss Psychology Open*

1 Introduction

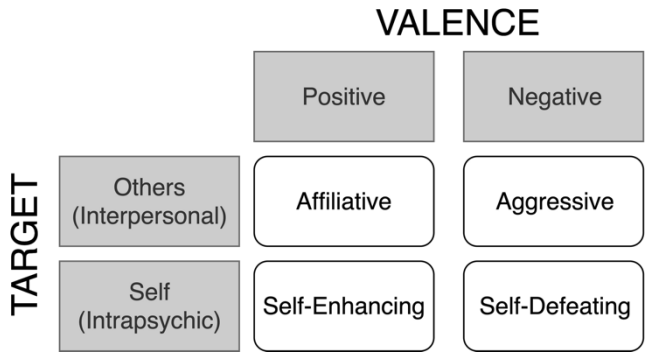
Humor plays an important role in humans' everyday communication and serves a variety of social, cognitive, and emotional functions. Indeed, research has shown that humor development improves socio-cognitive skills (Soy Telli & Hoicka, 2022), fosters social interactions by improving self-confidence (Nezlek & Derks, 2001), and promotes reciprocal liking (people typically like those who make them laugh) (Treger et al., 2013), and contributes to group cohesiveness (Martin et al., 2003). More importantly, humor contributes to life satisfaction (Peterson et al., 2007) and can have a positive impact on psychological well-being (Curran et al., 2021; Kuiper, 2012; Papousek, 2018). Indeed, the production of humor has been shown to be a powerful means of down-regulating negative emotions in oneself (Kugler & Kuhbandner, 2015; Samson et al., 2014; Samson & Gross, 2012; Strick et al., 2009) and in others (Horn et al., 2018; Papousek, 2018). Moreover, it can also be used to upregulate positive emotions (Geisler & Weber, 2010; Samson et al., 2014; Samson & Gross, 2012), which are widely known as having a strong, positive impact on well-being (Fredrickson, 2004).

However, all of these positive effects of humor on well-being seem to occur under one condition: humor has to be benevolent, harmless, and benign. But humor also has a dark side, when it is depreciating, hostile and harmful, and can negatively impact psychological well-being (Samson & Gross, 2014). Depreciating mockery can affect negatively the targeted person, and this can have strong consequences such as the development of gelotophobia, which is the fear of being laughed at (Ruch & Proyer, 2008a) leading individuals to experience high fear and anger when exposed to ridicule (Platt, 2008) and to difficulties developing close relationships (Brauer et al., 2020). Whether humor plays a positive or negative role in psychological well-being depends notably on the nature of the specific type of humor involved, and more specifically on whether it is good- or ill-intentioned and whether it is well or badly perceived.

Martin *et al.* (2003) defined four humor styles, on the basis of a 2x2 categorization, as depicted in Figure 1.

Figure 1

Representation of Martin et al.'s (2013) 2x2 categorization of humor styles, adapted by the author.



The styles are thus defined according to whether the type of humor is *interpersonal* (i.e., directed towards others and with the purpose of increasing or decreasing others' psychological state and one's relation with others) or *intrapsychic* (directed towards oneself and with the purpose of increasing one's own well-being). The second part of the categorization relies on whether individuals use humor that is rather *positive* (benevolent, harmless, and benign), or *negative* (detrimental, hostile, and harmful). The four resulting humor styles are as follows (Martin et al., 2003): *Affiliative humor* (interpersonal and positive) represents the tendency to say funny things, amuse others, engage in humorous interactions with others to enhance the relationship and reduce potential tensions. It is intended to make others laugh in a benevolent and benign manner. This style of humor correlates positively with cheerfulness, extraversion, openness to experience, self-esteem, social intimacy, and psychological well-being, and correlates negatively with seriousness, bad mood, anxiety, and depression. *Aggressive humor* (interpersonal and negative) represents a form of humor produced to the detriment of others. It can be hurtful, as the one engaging in such humor will produce hostile mockery, ridicule, or derision. It can also be used as a manipulative tool, by threatening the other to get ridiculed. Such humor correlates positively with neuroticism, hostility, and aggression, and negatively with agreeableness, conscientiousness, and seriousness. *Self-enhancing humor* (intrapsychic and positive) is produced to enhance one's own well-being, by using humor to cope with stress, and regulate one's own emotions. Individuals who are high on this dimension have a tendency to generally look at life, its incongruities and adversities, with an amused and humorous eye. It correlates positively with cheerfulness, optimism, self-esteem, well-being, openness, and extraversion, and correlates negatively with bad mood, depression, anxiety, and neuroticism. *Self-defeating humor*

(intrapsychic and negative) involves self-disparaging humor, that is, trying to integrate or gain approval by letting others mock and ridicule oneself. It also includes a tendency to avoid and deny the problems by engaging in humorous behavior to hide negative feelings (which is different from positive humorous coping behavior, since here it is a matter of denial and not reappraisal). It correlates positively with bad mood, depression, anxiety, neuroticism, hostility, and aggression, as well as with shyness (Hampes, 2006), and correlates negatively with psychological well-being, self-esteem, agreeableness, and conscientiousness.

In terms of the relation between humor and psychological well-being, it appears that it is really *positive* humor, i.e., affiliative and self-enhancing humor, that has a positive impact. Samson and Gross (2012) have shown that positive (i.e., benevolent) humor was substantially more efficacious than negative humor in down-regulating negative emotions. Cann and Collette (2014) showed that *only* self-enhancing humor was related to positive stable affect and thus to psychological well-being (Fredrickson, 2004), while Kuiper (2012) highlighted that only positive humor contributes to resilience. Overall, research has widely confirmed that affiliative and self-enhancing humor has a positive impact on well-being, whereas self-defeating humor has a negative impact on well-being (Dyck & Holtzman, 2013; Martin et al., 2003; Schneider et al., 2018), and this appears to be true independently of culture and age (Jiang et al., 2020). Moreover, a higher use of self-defeating humor and lower use of self-enhancing and affiliative humor correlate positively with increased depressive-symptoms (Frewen et al., 2008).

Although research has mainly investigated the influence of humor styles on individuals' well-being, it is also very likely that well-being influences individuals' relation towards humor. Indeed, in the broaden-and-build model, Fredrickson (2004) suggests that positive emotions and psychological well-being influence each other in a loop. Indeed, according to the model, positive emotions broaden the mind to new experiences, which contributes to building personal resources that will in turn enhance mental health and well-being (Fredrickson, 2013). This state of enhanced health and well-being brings individuals to be more open to experiencing positive emotions, which creates a virtuous spiral. As such, it seems highly likely, not only that positive humor influences well-being and mental health, but also that well-being and mental health influence one's relation towards more positive and negative humor.

Humor is intrinsically social by nature. Indeed, it usually occurs in social interactions (Provine, 2000), which might imply that individuals with higher social motivation and abilities will have a greater relation towards humor. Additionally, humor processing requires quite high

socio-cognitive skills, since the understanding of humor often relies on inferring the joker's intentions (i.e., that they have the intention to produce humor and not an unintentional mistake or a lie) (Hoicka & Gattis, 2008; Ruch, 2008). As such, individuals who show lower social motivation or difficulties with social cognition, such as individuals with autism spectrum disorder might have a more conflictual or less evident relation towards humor.

Autism spectrum disorder (ASD) has a median prevalence of 100 in 10,000 individuals worldwide and in Europe (Zeidan et al., 2022). The spectrum is characterized by two main criteria: difficulties in social communication and social interaction, and restrictive interests and repetitive behaviors (DSM-5-TR, American Psychiatric Association, 2022). Autistic individuals tend to experience several difficulties in the social domain, notably in relation to mindreading abilities (Baron-Cohen, 2001; Senju, 2012), and a rather low social motivation which implicates to seek less for social interactions (Chevallier et al., 2012a). They also seem to have a negativity bias, in the sense that they tend to experience negative emotions more frequently (Samson et al., 2012) and are described as being rather serious and not very cheerful (Samson et al., 2013; Treichel, Dukes, Meuleman, et al., 2023). These characteristics impact autistic individuals' particular relation towards humor (Treichel et al., 2022), and notably the humor styles they tend to produce.

Samson et al. (2013) showed that autistic adults without intellectual disabilities scored lower than typically developing adults in both positive types of humor (i.e., affiliative and self-enhancing humor), but no difference appeared in aggressive and self-defeating humor. They argued that the reported lower scores of autistic individuals in affiliative humor might be related to their difficulties in the social domain. Moreover, the authors pointed out that autistic individuals' lower scores in self-enhancing humor could be related to their difficulties in regulating their emotion (Samson et al., 2012, 2015). It could also be argued that these results are highly coherent with autistic individuals' negativity bias (Joseph & Tager-Flusberg, 1997; Samson et al., 2012), which seems to impact their general humor temperament (Samson et al., 2013; Treichel et al., 2022).

Autistic people seem to be at the opposite pole of a social motivation spectrum compared to individuals with Williams syndrome and Down syndrome (Treichel et al., 2022) who have been described as having high social motivation, which is a pronounced tendency to seek out social interactions. Williams syndrome (WS) is a rare genetic disorder that concerns approximatively 1 in 10,000 births (Morris & Mervis, 2021), involving mild to moderate intellectual disabilities (Korenberg et al., 2000), that is notably characterized by a particularly high social approach tendency and an overly friendly and disinhibited personality

(Järvinen et al., 2013; Jones et al., 2000). People with WS are also described as highly cheerful (Tager-Flusberg & Sullivan, 2000; Treichel, Dukes, Meuleman, et al., 2023), and particularly expressive when it comes to positive emotions (Treichel, Dukes, Barisnikov, et al., 2023). Down syndrome (DS) is a genetic disorder affecting roughly 1 in 800 births (Lanphear & Castillo, 2007) that notably involves intellectual disabilities (Antonarakis et al., 2020; Määttä et al., 2006). Individuals with DS have notably been described as very sociable (Porter et al., 2007) and cheerful (Grieco et al., 2015; Treichel, Dukes, Meuleman, et al., 2023). Although they differ greatly from ASD on the social motivation level, WS and DS share some important similarities with ASD (Klein-Tasman et al., 2009; Niego & Benítez-Burraco, 2022; Reilly, 2009). For example, individuals with WS and DS present with difficulties in social cognition and communication (Channell, 2020; Fisher & Morin, 2017; Neitzel & Penke, 2021; Tager-Flusberg & Sullivan, 2000), in mindreading abilities (Neitzel & Penke, 2021; Tager-Flusberg & Sullivan, 2000), and in sustaining friendships (Iarocci et al., 2008; Järvinen et al., 2013). Moreover, ASD, WS, and DS all show a tendency to develop mental health problems such as anxieties, specific phobias, hyperactivity, and depression (Lai et al., 2019; Määttä et al., 2006; Stinton et al., 2010), as well as increased rates of bullying experiences (Cappadocia et al., 2012; Fisher et al., 2017a; Jackson et al., 2014).

So far, little research has been conducted on humor in WS and DS (for reviews, see Chadwick & Platt, 2018; and Treichel et al., 2022), and to our knowledge, no studies have investigated humor styles in either of these neurodevelopmental conditions. Moreover, studies on humor in ASD have focused on adults and only on individuals *without* intellectual disabilities, which is not entirely representative of the spectrum[14]. It follows that comparisons in humor styles between ASD, DS, and WS do not exist. Doing so could be helpful to highlight potential syndrome-specificities, to allow a more transdiagnostic approach of studying humor in neurodevelopmental conditions, and to understand the role of particularities in social abilities and mental health on individuals' relation towards humor.

The goal of this study is (1) to examine whether the general tendency of autistic individuals to engage less in positive (affiliative and self-enhancing) humor is replicated in a younger and cognitively diversified sample, (2) to discover which types of humor individuals with WS and DS engage in, and (3) to shed light on the possible influence of social difficulties and mental health on the propensity to use different types of humor. Considering the

[14] It should however be specified that these studies ran before the new DSM-5, when Asperger syndrome was still a separate and specific diagnosis from autism.

important role that positive humor can play in regulating emotions and enhancing well-being, it is crucial to better understand the extent to which individuals with different neurodevelopmental conditions engage in different types of humor.

In the present study, questionnaires were distributed to parents of autistic individuals (with and without intellectual disabilities) and of individuals with WS or DS, to assess which humor styles they tend to employ, as well as to assess individual differences in social difficulties (including social awareness, cognition, communication, and motivation) and mental health problems (social, emotional, or behavioral). We expected that autistic individuals would show a lower tendency to engage in positive forms of humor and a higher tendency to engage in self-defeating humor compared to individuals with WS and DS. Moreover, we expected social difficulties related to social motivation and social cognition to be negatively correlated with positive forms of humor and positively correlated with negative forms of humor. We also hypothesized that higher levels of emotional, behavioral, and social problems related to mental health would be related to less positive humor styles and less negative humor styles.

2 Methods

2.1 Participants

Initially, and after a data cleaning procedure explained in the following section, 230 parents took part in the study. Participants were asked to report whether their child was verbal or non-verbal. Considering that the questionnaire on humor styles notably assesses the use of humor in verbal communication, only participants who reported their child to be verbal were kept in the following analysis. As such, the final cohort consisted of 147 parents of young individuals with ASD (N = 31), DS (N = 82), or WS (N = 34). Most participants (93.2%) described their child as being Caucasian, with a few (6.1%) describing them as having mixed ethical origins, and one (0.7%) as being Asian. 83.9% of participants lived in England, 7.4 % in Scotland, 2.7 % in Wales, 2% in Ireland, 1.4 % in Northern Ireland, and the remaining 2.8% were spread between Japan, USA, Canada, and Portugal.

Table 1

Participants' characteristics

	ASD (n = 31)	DS (n = 82)	WS (n = 34)
Sex (Female/Male)	5/25	41/41	12/22
Intellectual disabilities (with/without)	18/13	82/0	34/0
Age (average in years (standard error)	10.68 (.71)	11.77 (.64)	11.76 (.93)

Note: ASD autism spectrum disorder, *DS* Down syndrome, *WS* William syndrome. One parent in the ASD group did not indicate their child's sex.

Table 1 presents the children's characteristics. A one-way ANOVA revealed there was no significant difference in mean age between the three groups, $F(2, 144) = .508$, $p = .603$. A Pearson chi-square test revealed a significant difference in the sex distribution between the groups, $X^2(2, 146) = 10.56$, $p = .005$. This difference is explained by the higher prevalence of ASD diagnosis in males than females, which is representative of the general tendency and not just a peculiarity of the current cohort: Zeidan et al. (2022) estimate a median male-to-female ratio of 4.2 across several international studies. In this study the male-to-female ratio is 5.0.

There was also a significant group difference in the presence or not of an intellectual disability, $X^2(2, 147) = 53.36$, $p < .001$. This is due to the heterogeneity of cognitive abilities in the ASD group (Charman et al., 2011). Indeed, individuals with DS and WS are typically characterized by having intellectual disabilities (Chapman & Hesketh, 2000; Korenberg et al., 2000), which is not necessarily the case with autistic individuals. However, differences in humor styles between individuals with and without intellectual disabilities in the ASD group should and will be controlled for.

2.2 Procedure

Participants were recruited in the UK: an advertisement was distributed to specific groups on social media, sent to schools, associations, and parents who had previously participated in other studies. The current study is part of a larger survey-based project on different socio-emotional processes in individuals with neurodevelopmental conditions. In this context, in exchange for £50 in total, parents were asked to answer a series of 23 questionnaires distributed in three parts. The questionnaires in the current study included the ones used in the first part of the project. The inclusion criteria were that participants needed to be parents of a child with ASD, DS, or WS, aged between 5 to 25 years-old. To avoid as

much as possible "scammer" participants (Pellicano et al., 2023), we established a few strategies, during and after recruitment: (1) we checked the IP addresses and excluded participants who's IP addresses appeared several times (with the exception of one family with twins that the researchers were aware about); (2) participants were asked to send an email to us indicating their child's age and diagnosis and the link to the study was sent only to those who wrote to us (the email addresses and names were not kept in the data set of the analysis in order to keep the study anonymous), (3) the questionnaire included a few redundant questions, e.g., asking for the date of birth as well as the age, and only the participants for which the calculated and reported ages matched were kept, (4) respondents who answered the same response to all questions (e.g., always checking "1" on the likert scales) were excluded, and (5) respondents who responded in less than 10 minutes (the whole study included 10 questionnaires, with a total of 260 items) were excluded. The first round of recruitment led to a lot of fraudulent attempts to participate so some of these measures were implemented subsequently. Indeed, there were initially 1,070 answers on the Qualtrics platform online, but only 230 remained after checking and cleaning the data according to the criteria mentioned above. Given the initial and subsequent measures taken, we are confident that only data given by genuine participants has been analyzed.

The local institutional review board of Unidistance Suisse approved the study protocol.

2.3 Instruments

For this study, data from 4 questionnaires was analyzed to assess gelotophobia, social impairment, affective predispositions and humor temperament.

2.3.1 Socio-demographic information and diagnosis

Before answering the specific questionnaires, parents were asked a series of socio-demographic questions, such as the age, sex and ethnic origins of their child. They were also asked which diagnosis their child had (with a selective list which included ASD, DS, and WS), as well as whether their child was verbal or non-verbal, and whether they had an intellectual disability or not. Only children who were described as being verbal were included in this study.

2.3.2 Humor style

To assess different humor styles, we used the Humor Style Questionnaire for children (HSQ-c, Fox et al., 2013), which is a simplified version of the Humor Style Questionnaire

(HSQ, Martin et al., 2003). Compared to the original HSQ, the HSQ-c is shorter (24 items instead of 32), the scale is of 4-points instead of 7-points, and it uses simpler formulations. As in the HSQ, the HSQ-c assesses children's use of four different humor styles, corresponding to four different subscales: affiliative, aggressive, self-enhancing, and self-defeating. The child version was preferred for reasons related to the larger project of which this study is only a part. For the present study, items were adapted for parent-report. A 4-points scale was used: (1) strongly disagree, (2) disagree, (3) agree, (4) strongly agree. A score for each subscale can be calculated, ranging from 6 to 24.

2.3.3 Social difficulties

The Social Responsiveness Scale[15] (SRS-2, Constantino & Gruber, 2012) is built to assess the severity of autism symptoms and general social impairments. It is rated on a 4-points scale, from (1) not true to (4) almost always true, contains 65 items and 5 subscales: social awareness, social cognition, social communication, social motivation, and restricted interests and repetitive behavior. It is parent-reported and exists in different versions according to the child's age (specifically, one version for children under 18, and one for adults equal or above 18).

A raw score of each subscale can be separately calculated, the range depending on the number of items in each subscale (social awareness: 8-32; social cognition: 12-48; restrictive repetitive behavior: 12-48, social communication: 22-88; social motivation: 11-44). A total raw score can also be calculated for each participant, including all the items and based on which cut-offs have been defined to evaluate the severity of autistic symptoms and social impairments. Only raw scores were used in the present study.

2.3.4 Mental Health

The Strengths and Difficulties Questionnaire (SDQ, Goodman, 1997) is a widely used questionnaire in research and in practice to assess children and young individuals' mental health. It is notably used to assess the severity of symptoms (emotional, behavioral, and social) and to evaluate the impact of different conditions on the individuals' emotional, behavioral, and social lives. It has been shown as being a consistent tool to measure socio-emotional difficulties as co-occurring conditions in ASD (Findon et al., 2016; Salayev &

[15] For the online administration of the SRS-2, the principal investigator of this research obtained the permission to adapt the format for specific, limited research use under license of the publisher, WPS (rights@wpspublish.com).

Sanne, 2017). In the current study, different parent-report versions were used, according to the participant's child age (younger than 4 years-old, between 4 and 17 years-old, and 18 years-old and more). Each version contains the same number of items but the formulation changes to correspond to the environment and behaviors of individuals of different ages. Parents are asked "For each item, please select the answer that best describes your child's behavior ", and their rating is done with a 3-points scale: (0) not true, (1) somewhat true, (2) certainly true. It contains 25 items divided between 5 subscales (5 items each): emotional problems, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behavior. For each subscale, a score can be calculated, ranging from 0 to 10. Cut-offs have been defined to assess the severity of symptoms, but only raw scores were used in the present study.

2.4 Analysis

The analysis was conducted with the software IBM SPSS Statistics version 25. First, we evaluated the reliability of each scale and subscale, for all groups together and each group separately, by calculating the Cronbach's alpha. Scales were considered as reliable, with $\alpha C \geq 0.7$.

Second, we calculated descriptive statistics (i.e., means and standard errors) for each subscale and each group separately. For each subscale from the HSQ-c, SRS and SDQ, as well as age and sex, we looked at group differences by running one-way ANOVAS and Student t-tests. We ran Pearson correlations using dummy variables (1;0) for the groups and gender, to determine potential correlations between all the variables (groups, demographic information, and subscales). For the humor styles, we also ran an ANOVA to determine whether there were differences in the scores between individuals with and without intellectual disabilities in the ASD group.

Finally, in the case of significant correlations between groups and humor styles, two multiple linear regressions were run (two models), with the respective humor style as the dependent variable. In the first model, the groups (ASD, DS, and WS) were used as independent variables. Since dummy variables were used, ASD was considered as the reference variable and DS and WS entered into the regression. In the second model, the groups remained, and demographic information (i.e., sex and age) and individual traits (scores in the respective subscales of the SRS and SDQ) were entered as additional independent variables. Non-violation of the following assumptions were tested: a test of multicollinearity was computed, with the assumption that a problem occurs if the variance

inflation factor (VIF) is greater than 10, and the tolerance statistic is lower than 0.1; influential cases were investigated by looking at the Cook's distance, which is assumed to be between 0 and 1 in the case of non-influential cases; normality of residuals was tested by computing normal P-P plots and histograms, and heteroscedasticity was tested by running a scatterplot with regression standardized predicted value in the x axis and regression standardized residuals in the y axis.

To overcome false positive results while maintaining a good reproducibility of the results, a reduced significance level of $\alpha = 0.005$ was applied to all the inferential tests of the following analysis (Benjamin et al., 2018).

3 Results

3.1 Reliability analysis

Table 2

Reliability analysis – Cronbach's alphas

	ALL	ASD	DS	WS
Humor Style Questionnaire for children (HSQ-c)	**.820**	**.817**	**.831**	**.838**
Affiliative	.809	.778	.810	.821
Aggressive	.500	.446	.580	.527
Self-Enhancing	.843	.839	.865	.777
Self-Defeating	.846	.895	.761	.780
Social Responsiveness Scale (SRS)	**.962**	**.924**	**.965**	**.949**
Social Awareness	.564	.333	.631	.611
Social Cognition	.821	.806	.835	.789
Social Communication	.899	.800	.904	.856
Social Motivation	.868	.709	.877	.792
Restrictive interests and repetitive behaviors	.885	.751	.898	.872
Strengths and Difficulties Questionnaire (SDQ)	**.742**	**.556**	**.754**	**.716**
Emotional problems	.812	.690	.793	.670
Conduct problems	.676	.557	.606	.701
Hyperactivity	.751	.724	.794	.730
Peer problems	.656	.412	.724	.417
Prosocial behavior	.776	.764	.754	.710

Note. ASD autism spectrum disorder, *DS* Down syndrome, *WS* William syndrome.

As revealed in Table 2, reliability analysis showed that overall, when all groups were considered together, all the scales reached acceptable reliability ($\alpha C \geq 0.7$). However, the SDQ did not reach an acceptable score for the ASD group ($\alpha C = .56$). HSQ – Aggressive and SRS – Awareness did not reach an acceptable score for any of the groups. SDQ – Emotional

problems and SDQ – Peer problems were below 0.7 for the ASD and WS groups and SDQ – Conduct problems was below the acceptable score for the ASD and DS group. Thus, interpretation of the following results should be done cautiously.

3.2 Group differences

Table 3

Descriptive statistics and group differences

	ASD (n = 31)	DS (n = 82)	WS (n = 34)					
Scale	**Mean (SE)**	**Mean (SE)**	**Mean (SE)**	**df**	***SS***	***MS***	***F***	***p***
HSQ-c – Affiliative	16.23 (.69)	18.65 (.41)	17.38 (.68)	2, 142	138.24	69.12	4.87	.009
HSQ-c – Aggressive	15.93 (.54)	15.25 (.35)	15.26 (.49)	2, 142	11.05	5.52	.58	.559
HSQ-c – Self-Enhancing	13.87 (.83)	13.47 (.47)	12.29 (.63)	2, 142	46.27	23.13	1.33	.267
HSQ-c – Self-defeating	13.70 (.91)	9.02 (.35)	10.00 (.63)	2, 142	480.69	240.34	17.41	.000
SRS – Social awareness	12.93 (.61)	9.79 (.44)	11.06 (.67)	2, 141	220.8	110.4	7.57	.001
SRS – Social cognition	20.27 (1.07)	16.04 (.74)	20.24 (1.04)	2, 141	630.18	315.09	7.87	.001
SRS – Social communication	35.73 (1.49)	22.42 (1.2)	26.03 (1.72)	2, 141	3880.37	1940.19	19.13	.000
SRS – Social motivation	18.37 (.86)	10.72 (.75)	9.91 (.98)	2, 141	1491.59	745.79	19.73	.000
SRS – Restrictive interests and repetitive behaviors	21.23 (.99)	14.96 (.93)	18.18 (1.3)	2, 141	919.83	459.91	7.93	.001
SDQ – Emotional problems	6.47 (.41)	2.63 (.28)	4.41 (.44)	2, 135	328.04	164.02	27.93	.000
SDQ – Conduct problems	4.77 (.41)	2.41 (.21)	2.47 (.37)	2, 135	128.72	64.36	16.40	.000
SDQ Hyperactivity	7.10 (.42)	6.28 (.27)	8.09 (.35)	2, 135	76.29	38.15	7.41	.001
SDQ Peer problems	5.60 (.37)	3.12 (.25)	4.03 (.33)	2, 135	133.55	66.78	15.07	.000
SDQ Prosocial behavior	4.90 (.45)	7.11 (.24)	6.19 (.4)	2, 135	106.724	53.36	10.87	.000

Note. ASD autism spectrum disorder, *DS* Down syndrome, *WS* Williams syndrome, *HSQ-c* humor styles questionnaire for children, SRS social responsiveness scale, SDQ Strengths and Difficulties Questionnaire.

As shown in Table 3, there was a significant group difference between ASD, DS, and WS in the use of one humor style: self-defeating humor. Additional paired-sample t-tests revealed that the ASD group showed a higher level of self-defeating humor (M = 13.7, SD = 5) than both the DS group (M = 3.02, SD = 3.15), $t(109) = 5.86$, $p < .001$, and the WS group (M = 10, SD = 3.64), $t(62) = 3.41$, $p = .001$, but no group difference appeared between WS and DS, $t(113) = -1.44$, $p = .151$.

Table 3 also reveals significant group differences in all the subscales from SRS and SDQ. Cut-offs percentages defining the distribution of severity of symptoms for each subscale per group can be found in Supplementary material. The raw means as reported in Table 3 indicate that, generally speaking, autistic individuals are reported to show greater social difficulties (higher scores in the SRS, SDQ – peer problems and lower score on SDQ – prosocial behavior) than individuals with DS and WS. However, individuals with WS score very similarly to individuals with ASD in social cognition difficulties $t(61) = .02$, $p = .987$, and more highly than both other groups in hyperactivity.

3.3 Correlations

Table 4 shows the results of a Pearson correlation between all the variables used in the present study. Interestingly, the diagnosis of autism correlated with all the subscales, with the exception of age, aggressive humor, self-enhancing humor, and hyperactivity. Similarly, the diagnosis of DS correlates with all the subscales with the exception of age, aggressive humor, and self-enhancing humor. However, the diagnosis of WS seems to correlate with none of the subscales with the exception of social cognition, social motivation, and hyperactivity. In terms of the humor styles, only affiliative and self-defeating humor correlate with the diagnoses, with ASD and DS, respectively.

Table 4

Correlations scores between all demographic variables and subscales of each questionnaire

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Autism	1																			
2. Down Syndrome	-.585***	1																		
3. Williams syndrome	-.287***	-.609***	1																	
4. Female	-.247*	.242*	-.047	1																
5. Male	.247*	-.242*	.047	-1***	1															
6. Age	-.096	.056	.027	.133	-.133	1														
7. HSQ-c Affiliative	-.215	.233*	-.068	-.058	.058	-.088	1													
8. HSQ-c Aggressive	.090	-.054	-.023	-.096	.096	.018	.193	1												
9. HSQ-c Self-Enhancing	.073	.052	-.131	-.120	.120	-.156	.466***	.061	1											
10. HSQ-c Self-Defeating	.433***	-.328***	-.030	-.136	.136	-.051	-.052	.112	.436***	1										
11. SRS Awareness	.283**	-.270**	.044	-.079	.079	-.081	-.342***	.018	-.197	.236*	1									
12. SRS Cognition	.185	-.317***	.195*	-.047	.047	.068	-.478***	-.044	-.316***	.221	.774***	1								
13. SRS Communication	.443***	-.363***	.000	-.104	.104	.007	-.479***	.019	-.211	.364***	.804***	.803***	1							
14. SRS Motivation	.465***	-.232*	-.176*	-.064	.064	.147	-.504***	-.083	-.210	.277**	.581***	.63***	.778***	1						
15. SRS Repetitive behavior	.273**	-.292***	.081	-.136	.136	.055	-.294***	.144	-.218	.247*	.742***	.773***	.813***	.614***	1					
16. SDQ Emotional problems	.479***	-.484***	.102	.042	-.042	.138	-.451***	.000	-.139	.405***	.429***	.510***	.613***	.671***	.506***	1				
17. SDQ Conduct problems	.442***	-.267**	-.117	.028	-.028	-.009	-.126	.162	.105	.487***	.302***	.272**	.437***	.314***	.371***	.524***	1			
18. SDQ Hyperactivity	.050	-.281**	.283**	-.045	.045	-.266**	-.106	.141	-.152	.030	.516***	.502***	.421***	.220	.511***	.342***	.191	1		
19. SDQ Peer problems	.396***	-.361***	.039	-.013	.013	.170	-.414***	.117	-.196	.327***	.563***	.536***	.703***	.609***	.536***	.612***	.429***	.283**	1	
20. SDQ Prosocial behavior	-.338***	.325***	-.052	.054	-.054	.095	.416***	-.176*	.164	-.195	-.489***	-.422***	-.513***	-.488***	-.373***	-.396***	-.333***	-.236*	-.481***	1

Note: HSQ-c Humor style questionnaire for children, SRS Social Responsiveness Scale, SDQ Strengths and Difficulties Questionnaire. * ≤ .005, ** ≤ .001, *** > .001

3.4 Regression analysis

Considering that the groups differed only in the use of self-defeating humor, a regression analysis was run with HSQ-c – Self-defeating as dependent variables.

Table 5

Regression analyses with HSQ-c – Self-defeating humor as dependent variable

Variable	B	95% CI for B		SE B	β	p
		LB	UB			
Model 1 – Diagnosis						
(Constant)	13.7	12.36	15.04	.68		.000
DS (vs ASD)	-4.68	-6.25	-3.11	.79	-.57	.000
WS (vs ASD)	-3.7	-5.54	-1.86	.93	-.38	.000
Model 2 – Individual differences						
(Constant)	7.18		2.12	2.56		.006
DS (vs ASD)	-1.78		-3.84	1.04	-.22	.090
WS (vs ASD)	-1.03		-3.35	1.17	-.11	.384
Age	-.11		-.25	.07	-.14	.103
Sex	1.21		-.1	.66	.14	.070
SRS – Social awareness	.04		-.25	.15	.04	.791
SRS – Social cognition	.001		-.19	.1	.001	.994
SRS – Social communication	.09		-.06	.08	.25	.232
SRS – Social motivation	-.05		-.22	.09	-.08	.587
SRS – Restrictive interests and repetitive behaviors	-.02		-.17	.07	-.04	.766
SDQ – Emotional problems	.28		-.09	.19	.19	.132
SDQ – Conduct problems	.59		.24	.18	.32	.001
SDQ Hyperactivity	-.4		-.75	.18	-.23	.023
SDQ Peer problems	.04		-.35	.2	.02	.836
SDQ Prosocial behavior	.22		-.1	.16	.13	.180

Note: Diagnosis ASD is used as a reference dummy variable, with DS and WS dummy variables included in the model. *ASD* autism spectrum disorder, *DS* Down syndrome, *WS* Williams syndrome, *HSQ* Humor style questionnaire, *SRS* Social Responsiveness Scale, *SDQ* Strengths and Difficulties Questionnaire.

Table 5 reports the scores on the two models of the regression analyses for HSQ-c - Self-defeating humor as dependent variable. Model 1, which includes the diagnoses as independent variables, is statistically significant, $\Delta R2 = .186$ $F(2, 142) = 17.41$, $p < .001$. Model 2, including in addition all the subscales of SRS and SDQ, is also significant $\Delta R2 = .32$, $F(14, 121) = 5.53$, $p < .001$, and explains a higher percentage of variance (32%) than model 1 (19.7%). The diagnoses are not significant anymore on this second model, and one variable of the SDQ appears as predictor of self-defeating humor: conduct problems.

4 Discussion

Humor can be a strong tool to regulate emotions and enhance well-being. However, research has shown that this seems to be the case primarily with positive humor styles, suggesting that individuals who use less positive humor may benefit to a lesser degree from the positive effects of humor on psychological well-being. Research has shown that autistic adults without intellectual disabilities tend to use less positive humor, compared to TD individuals (Samson et al., 2013). This might impact their use of humor as a strategy to regulate their own emotions, as well as their overall well-being. It has notably been shown that autistic individuals are more prone to develop a fear of being laughed at (Samson et al., 2011; Treichel, Dukes, Meuleman, et al., 2023). The aims of the present study were to examine whether less frequent use of positive humor also appeared in younger and more cognitively diversified autistic individuals. Moreover, it examined the use of different humor styles in individuals with other neurodevelopmental conditions, namely WS and DS. Humor styles in these two conditions has, to our knowledge, not been tested before, and, it follows, no comparison study has ever been carried out. Finally, this study assessed the link between humor styles and different social, psychological, and behavioral characteristics, to examine the potential influence of social difficulties and mental health on the propensity to use different types of humor.

Results revealed that autistic individuals used significantly more *self-defeating* humor than both individuals with WS and with DS.

In a study comparing autistic and TD adults, Samson et al. (2013) observed a less frequent use of both positive humor styles in ASD. More recently, Samson et al. (2022) showed that young autistic individuals *with* intellectual disabilities used substantially less humor as an emotion regulation strategy than individuals with other neurodevelopmental conditions, including WS and ASD *without* intellectual disabilities. These studies might imply that a lower use of positive humor, whether inter-personal or intrapsychic, is a specificity of the spectrum, although, so far, little is known about emotion regulation strategies in other neurodevelopmental conditions (England-Mason, 2020). The results of the present study seem rather to suggest that the use of positive humor is not different between ASD (with and without intellectual disabilities), DS, and WS, since no significant group differences in the use of *self-enhancing* and *affiliative* humor were found. Comparison with a TD group would be necessary in the future to drive clearer conclusions, but it appears that the less frequent use of positive humor previously observed in autistic individuals (Samson et al., 2013, 2022) is not a unique characteristic of ASD but rather that it might concern several other

neurodevelopmental conditions. This might be partially related to their collective difficulties in some aspects of social communication. Indeed, Table 4 shows that affiliative humor seems to correlate negatively with all subscales of the SRS, as well as with peer-problems and prosocial behaviors, the social subscales of the SDQ. This is perhaps not surprising, since affiliative humor is, by its nature, social and directed towards others. Self-enhancing humor also correlates positively with social cognition. One possible interpretation is related to the fact that the difficulties individuals with neurodevelopmental conditions have in social cognition can notably lead to struggles in sustaining friendships (Iarocci et al., 2008; Järvinen et al., 2013; Petrina et al., 2014). Fewer and less deep friendships might in turn negatively influence individuals' own self-esteem (Keefe & Berndt, 1996), and self-esteem has been shown as being positively correlated with self-enhancing humor (Martin et al., 2003). It is therefore possible that individuals with neurodevelopmental conditions' difficulties in social interactions, which can be an impediment to building sustained and strong friendships, might be negatively related to self-esteem and the ability to use self-enhancing humor and affiliative humor. Future research should thus investigate this hypothetical link between social interaction, self-esteem (Riggio et al., 1990), and positive humor styles in neurodevelopmental conditions. However, to better interpret these results in light of the study by Samson et al. (2013), it has to be noted that their participants were adults – whereas the present study included children, adolescents and young adults - and they had no participants with intellectual disabilities - whereas the current study's sample is more cognitively diverse. In addition, the comparison groups differ: while Samson et al. (2013) included a group of TD individuals, the present study compared different neurodevelopmental conditions. Finally, Samson et al. (2013) used self-reports, whereas the present study used parent-reports. Any of these differences or a combination of them might explain why the current study does not confirm the existence of a particular relation of autistic individuals towards positive humor styles. It may be hypothesized that parents might be less able to report about this type of humor in particular, since it relates to intrapsychic mechanisms that are not necessarily perceptible from a third person's perspective. Indeed, parents might detect that their child uses humor, but the intention behind it (i.e., whether it is to cheer oneself up, or for any other reason) might be more difficult to detect.

While Samson et al. (2013) identified no differences in negative humor styles between autistic and TD individuals, the present study found a more frequent use of self-defeating humor in autistic individuals compared to individuals with DS and WS. Regression analysis showed that the stronger predictor for differences in self-defeating humor was conduct

problems, which belongs to the general category of "externalizing problems" of the SDQ[16] (Goodman et al., 2010). Conduct problems correlate positively with self-defeating humor and are much less concerning for individuals with WS and DS than for autistic individuals. Conduct problems include maladaptive behaviors such as having temper tantrums, fighting, lying, stealing, or disobeying. One possible explanation for the relation between conduct problem and self-defeating humor could be that maladaptive behaviors might lead individuals to have a poorer opinion of themselves. Indeed, the conduct problems defined in the SDQ are generally behaviors that do not respond to norms, social rules, and rules of conduct. As such, these behaviors can lead to negative responses coming from others, who witness them or are targets of them, and these negative responses might lead individuals who engage in such behaviors to have a poorer opinion about themselves and thus easily self-depreciate themselves. On the other hand, individuals who engage less in maladaptive behaviors will have less reason to self-depreciate themselves in the eyes of others. This would be consistent with previous research which has shown a negative correlation between self-defeating humor and self-esteem (Martin et al., 2003) and a positive correlation between self-esteem and conduct problems (Ha et al., 2008). Future research should investigate more thoroughly the link between self-esteem, externalizing mental health problems, and self-defeating humor in neurodevelopmental conditions.

The results of these regressions suggest that differences in humor processing should be understood from a transdiagnostic perspective, perhaps surpassing the strict definition of specific diagnoses in favor of focusing on psychological and neurological processes that can be common to different diagnoses and better highlight the origins of specific difficulties (Astle et al., 2022; Insel et al., 2010; Monestès & Baeyens, 2016). In our study, group differences have been observed in the use of self-defeating humor, but when individual differences were controlled for, the diagnoses did not appear as significant predictors anymore. These results suggest that a strictly observed difference between the conditions is limited in terms of our understanding of the origins of these specific behaviors. This is in line with a previous study led by the same author which showed differences between ASD, DS, and WS in the tendency to develop a fear of being laughed at (gelotophobia) were superseded by individual differences in humor temperament, namely bad mood and seriousness (Treichel, Dukes,

[16] The three general categories of the SDQ are : (1) Internalizing problems (emotional problems and peer relationships problems) ; (2) externalizing problems (conduct problems and hyperactivity) ; and (3) prosocial behavior (A. Goodman et al., 2010; R. Goodman, 1997)

Meuleman, et al., 2023). In the present study, externalizing mental health was an important predictor of differences in humor styles. In other words, the case of autism observed in this study is highly informative because it suggests that engaging more in self-defeating humor seems to be related to a higher tendency to develop mental health problems, which concerns autistic individuals, but also individuals who have the same difficulties who are not on the spectrum. Future studies should pursue the investigation of the origins of group differences and similarities, to understand their impact on humor processing. More specifically, I suggest that future research should focus on self-esteem and its relation with mental health, and investigate whether it could operate a mediator effect on self-defeating humor in individuals with different neurodevelopmental conditions. Such knowledge can help better understanding the particularities and similarities between diagnostic groups and may contribute to improving well-being of individuals with different neurodevelopmental conditions.

5 Limitations

While a particular strength of our study is that it is the first one to address humor styles in WS and DS and that it brings a transdiagnostic explanation to differences in humor styles in various developmental conditions, a few limitations have to be addressed. One limitation of the present study is that it did not include a TD group. Future studies should include mental age-matched and chronological age-matched TD participants, to allow a more precise interpretation of the specificities of ASD, DS, and WS in relation to humor styles. It would be interesting, for example, to test how individuals with WS and DS appear to engage in different humor styles comparatively to TD individuals, and whether young and more cognitively-diverse autistic individuals differ also from TD individuals in their use of positive humor styles. Another limitation of the current sample is the limited number of participants with ASD, when considering the higher prevalence of this condition in comparison with DS or WS (Sherman et al., 2007; Strømme et al., 2002; Zeidan et al., 2022). As such, future studies should include a larger group of participants with ASD. Finally, given the nature of the protocol, it was not possible to precisely assess the cognitive level of the young individuals with neurodevelopmental conditions. Future studies should thus add a more accurate evaluation of intellectual disabilities to get a better picture of the influence of cognitive abilities on humor processing in ASD, DS, and WS, compared to mental-age matched TD participants.

6 Conclusions

Humor can be highly beneficial for psychological and inter-personal well-being, but research has shown the differing influences of positive humor styles and negative humor styles. Thus, to bring new knowledge for future interventions aiming at improving the use of humor to enhance social interaction, psychological well-being, and emotion regulation, it is important to better understand how individuals with different neurodevelopmental conditions engage in positive and negative humor styles, which would also allow to better understand the conditions themselves. The results of the present study revealed that individuals with WS and individuals with DS seem to be less inclined than autistic individuals to engage in self-defeating humor, which seems to be related to fewer mental health problems (coherent with their positivity bias) in our study. The potential impact of social, emotional and behavioral strengths and difficulties in relation to self-esteem have been discussed and would need further investigation.

Transparency Statement

I reported how we determined the sample size and the stopping criterion. I reported all experimental conditions and variables. I report all data exclusion criteria and whether these were determined before or during the data analysis. I report all outlier criteria and whether these were determined before or during data analysis.

Data Availability

Data has been made available here: https://osf.io/dhqrw/?view_only=9d51a2083882437f8613795e303ae160

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2.4 Article 4: Appreciation of slapstick humour[17] and expressivity in response to amusing stimuli in individuals with Williams syndrome[18]

Abstract

Objectives: Previous studies on the comprehension and appreciation of humour in individuals with Williams syndrome (WS) have only included complex types of humour that required complex cognitive abilities. Additionally, although individuals with WS have been described as having a bias towards positive emotions, no study has investigated their expressive responses to humour.

Methods: The present study examined basic humour processing skills, as well as expressive responses to simple humorous and non-humorous stimuli in individuals with WS (N=8) compared to mental-age matched typically developing (TD) children (N=9). Participants were shown short funny and non-funny excerpts of the movies "Ice Age" and "Madagascar" and were asked to rate their level of amusement. Their expressive responses, namely smiles and laughs, were coded and analysed.

Results: Individuals with WS seem to be able to discriminate between humorous and non-humorous conditions and appreciate simple humorous content as much as TD individuals. As such, they are equally able to process simple type of humour as their mental-age matched counterparts. Additionally, and in line with their positivity bias, individuals with WS expressed more frequent and more intense laughter than the control group.

Conclusion: Individuals with WS appreciate simple humour as much as TD individuals, and they seem to display a particularly high expressivity in response to humorous stimuli.

Keywords: Williams syndrome; humour; laughter; expressivity; positivity bias

[17] This article was submitted to a journal that required the manuscripts to be written in Australian English. This style was kept in the present reprinted version.

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1 Introduction

Williams syndrome (WS) is a rare genetic disorder (it concerns 1 in 7,500 life births, Strømme et al., 2002) caused by a deletion of chromosome 7q11.23. Individuals with WS have mild to moderate intellectual or learning disabilities and specific cognitive strengths (notably relative to some aspects of language) and weaknesses (especially with visuospatial construction) (Mervis & Klein-Tasman, 2000). They are characterised by a very gregarious personality: They show high motivation to interact with others (Little et al., 2013), are generally described as being very cheerful (Tager-Flusberg & Sullivan, 2000), and have a bias towards positive affect (Järvinen et al., 2013). Despite their hypersociability, individuals with WS also present with difficulties in the socio-emotional domain: typically, they have been reported as having difficulties with the cognitive aspects of theory of mind (Porter et al., 2008), with some aspects of social communication such as joint attention (Laing et al., 2002), and with inhibiting their spontaneous behavioural responses (Menghini et al., 2010). These particularities notably lead individuals with WS to show more difficulties in sustaining friendships (Gillooly et al., 2022). The syndrome is also associated with an increased risk to develop mental health problems such as anxieties, fears and phobias, as well as attention deficits and hyperactivity (Leyfer et al., 2006).

At first sight, their cheerful and gregarious personality would suggest individuals with WS would particularly enjoy and master humour. However, their intellectual disabilities might rather generate difficulties in processing humour, which is actually a quite challenging cognitive task. Indeed, humour relies on resolving an incongruity (Suls, 1972). It supposes that any type of humour is based on the existence of an incongruity, i.e., on a (benign) violation of expectations, and that this incongruity has to be solved and be given a humorous meaning. This incongruity process involves three steps, each of which requires specific cognitive abilities: First, to detect the incongruity, one has to have knowledge about the norms and expectations that have actually been violated. Second, making sense of the incongruity (i.e., resolving the incongruity) requires high cognitive flexibility to be able to switch from one perception to another, that is: To find the right cognitive rule that would give a logical and humorous explanation to the incongruity (Klos, 2021; Martin & Ford, 2018). Third, one has to be able to involve all the contextual information necessary to understand that the sense of the incongruity relies on a humorous basis and is not merely a problem to be solved, or a lie (Ruch, 2008). Humour processing is thus cognitively quite challenging and not necessarily an easy task to accomplish, especially for individuals who might have cognitive impairments or difficulties with cognitive flexibility, such as individuals with WS (Rhodes et al. 2010).

Considering the importance of humour in our everyday life and all the positive benefits it bestows, it is important to better understand how it is understood and appreciated by individuals with different conditions. Indeed, humour (Kuiper et al., 2004) can enhance well-being (Curran et al., 2021; Martin et al., 2003) and contribute to build and maintain social interactions (Nezlek & Derks, 2001; Treger et al., 2013). Humour has also been shown to be an efficient strategy to regulate one's own or others' negative emotions (Horn et al., 2018; Kugler & Kuhbandner, 2015; Samson & Gross, 2012) and is therefore notably used in interventions (Ruch & McGhee, 2014). Recent findings have even provided evidence that interventions based on humour can reduce fears in individuals with WS (Klein-Tasman et al., 2022). Thus, such research can lead to a better understanding of affective and cognitive processes of individuals with WS, but also of humour itself.

So far, only a few studies have investigated how individuals with WS understand, appreciate and use humour (for an overview, see Chadwick & Platt, 2018; Treichel et al., 2023). Sullivan et al. (2003) showed that participants with WS seemed to have difficulties discriminating between a lie and a joke when they were presented with scenarios where the joke depended on the understanding of a character's mental state. Krishan et al. (2017) confirmed the difficulty that individuals with WS had with understanding a humorous content based on theory of mind, compared to chronological age-matched typically developing (TD) individuals, but they did not differ from mental age-matched control participants, or from individuals with Down syndrome. Finally, Godbee and Porter (2013) showed that individuals with WS had more difficulties than chronological age-matched TD individuals (but did not differ from the mental age-matched control group) in understanding non-literal language such as sarcasm, metaphors and similes.

Although a certain level of cognitive flexibility and abstraction is necessary to process humour in general, it seems that, so far, studies on humour in WS have mainly focused on types of humour that required quite advanced cognitive skills, such as mentalizing skills (Krishan et al., 2017; Sullivan et al., 2003) or functions, such as verbal working memory or inferential reasoning (Godbee & Porter, 2013). It is important to emphasise, however, that according to the content of a joke, different reasoning can be involved in humour processing (Attardo & Raskin, 1991), as well as different levels of difficulties. Thus, humour can necessitate a variety of cognitive abilities. Some types of humour, such as slapstick humour, turn out to be quite straight forward, without involving important social, verbal, or reasoning skills. Studying how individuals with WS process such simple types of humour would help understand whether their difficulties are related to the complexity of the jokes and cartoons

they were presented in previous studies, or whether they also have difficulties with basic humour processing.

In addition to the cognitive aspects, humour also involves an affective dimension, that is: A subjective emotional experience that is most often positive (e.g., amusement, mirth, or exhilaration) and results in physiological (Lackner et al., 2014; Shiota et al., 2011), bodily, and facial expressive responses, i.e., smiling and laughing) (Ruch, 2008). To the best of our knowledge, no studies have thus far investigated the emotional expressive response to humorous stimuli in individuals with WS. They are commonly described as frequently smiling and laughing, but this statement has yet to be investigated more thoroughly. As mentioned, individuals with WS have been described as having a bias towards positive emotions and as being rather cheerful (Treichel, Dukes, Meuleman, et al., 2023). Studies have investigated their bias towards positive expressions (Dodd & Porter, 2010) and their difficulties detecting negative expressions in others (Santos et al., 2010), but to our knowledge, no study has directly investigated individuals with WS' *own* facial expressions in response to non-social positive stimuli.

In order to examine the comprehension, appreciation and expressive response to simple types of humour in individuals with WS, the present study used a similar design to Weiss et al. (2013), who examined such phenomena in children with autism spectrum disorder (ASD) without intellectual disabilities. In that study, participants were presented a series of short videos extracted from the movies "Madagascar" and "Ice Age", half of which were meant to be humorous and trigger amusement, while the other half were supposed to be non-humorous, neutral. The amusing excerpts were based on slapstick humour and did not require theory of mind, verbal skills, or inferential reasoning to be understood. The participants were then asked to evaluate their level of amusement on a 5-point scale. Results showed that children with ASD enjoyed the humorous material as much as TD participants and were able to discriminate between funny and non-funny videos. Finally, the authors looked at the occurrences of smiles and laughter. Autistic individuals seemed to have expressions that did not always match their subjective ratings, suggesting a lower emotional coherence (i.e., the match between different emotional components, such as the subjective experience and outward expression of an emotion) than TD participants.

The present study was based on the same experiment, using the same stimuli, but the scale was adapted from a 5-points to a 4-points scale, to make it more accessible for individuals with intellectual disabilities. The subjective rating (i.e., the level of amusement) was compared between individuals with WS and TD individuals. Given their bias towards

positive emotions, we expected individuals with WS to experience and report a higher level of amusement (i.e., of a positive emotion) than TD individuals in the non-humorous condition and an equal level of amusement in the humorous condition. As such, on the assumption that the individuals with WS would show greater difficulty understanding when the content is supposed to be humorous or not compared to the TD group, we expected there to be less difference in their ratings of the humorous and non-humorous conditions. Moreover, the facial expressions of amusement were also examined. More specifically, the intensity and duration of laughter and smiling in response to each stimulus were examined. Again, considering their positivity bias and since they are described as being rather cheerful, it was hypothesised that individuals with WS would express longer and more intense smiles and laughter than TD individuals, independently of the condition.

2 Methods

2.1 Participants

All participants were recruited in Switzerland. Informed consent was obtained for each participant ad the study was approved by the Swiss Ethical Committee Board of Geneva (No.2017-01435). Seventeen participants successfully took part in the study: Eight individuals with WS, aged between 18 and 47 years old (M = 27.26, SD=9.23, Mdn = 24.21), and a comparison group of 9 mental age-matched TD children, aged between 6 and 9 years-old (M = 7.12, SD=1.03, Mdn = 6.58). The two groups were matched according to their non-verbal intellectual abilities, based on the mean scores of each group: The raw scores of the Raven's Colored Progressive Matrices (RCPM, Raven et al., 1990) for the WS group (M = 21.62, SD=7.96, Mdn = 21) and the TD group (M = 21.89, SD=5.67, Mdn = 22) did not differ (U = 34, z = −.193, p = .847). The two groups differed significantly in chronological age (U = .000, z = −3.47, p = .001, r = −.842). There was a clear difference in the gender distribution between the WS group (6 cisgendered females and 2 cisgendered males) and the TD group (2 cisgendered females and 7 cisgendered males), although a Fisher's exact test did not reveal a significant difference between the groups (2-tailed p = .057), which can be explained by the small sample size (rendering a Chi-square analysis unsuitable).

2.2 Procedure

Participants started by taking the RCPM test, which consists of a series of puzzles, to evaluate general non-verbal cognitive abilities. This test has been proven as an effective tool to match individuals with WS to a control group (Van Herwegen et al., 2011). The test was presented by an experimenter on printed paper sheets.

Then, the experimenters made sure the participants were able to understand a 4-point rating scale, as used in this study. Based on Cummins (1997) and Cuskelly et al. (2013), the experimenter tested (1) the tendency of the participant to use acquiescent responding, by asking a few questions such as "do you craft your clothes yourself?" (2) the ability to form opinions, by asking questions such as "do you like funny movies and why?", (3) the potential tendency of the participant to remember only the beginning or the end of a list (recency and primary effects), and, (4) discriminative competencies, by showing a physical model of the scale (i.e., four boxes of different sizes on which were printed the four smiley-faces that were later used in the task's scale). For this last step, participants were first asked to put the boxes in the right size order (from smaller to bigger and reverse). Then, the experimenter would make sure the participant understood the meaning of the scale and of each smiley-face, by giving examples, and then asking the participants to give some on their own. The experimenter then asked the participant to point to the smiley-face representing the neutral, small, medium and high levels of amusement.

Finally, participants would do the *simple humour comprehension and appreciation task*, adapted from the study by Weiss et al. (2013). Participants were shown 20 short scenes of 7 to 12 seconds each (M = 8.9, $S\ D$ = 1.41), extracted from the movies "Ice Age" and "Madagascar". 10 funny videos constituted the humorous condition, and 10 non-humorous ones were selected for the control condition. The videos were carefully selected by the authors of the study by Weiss et al. (2013) for their level of amusement and comprehensibility. Indeed, all the humorous videos are constituted of scenes based on simple slapstick humour, and the non-humorous videos were estimated as being rather neutral (not triggering any particular positive or negative emotion) by the authors. The task was presented on a laptop computer and was programmed on PsychoPy. After the instructions, the participants saw two examples to get familiar with the task. Then, the videos were presented in a pseudo-random order, with the coded instruction that the same condition (humorous or non-humorous) could not be presented more than twice in a row. Before each video, a fixation cross of 4 seconds appeared. After each video, the participant was given the possibility to watch it a second time or not. Finally, the participant would be asked the question "how amusing did you find this video?", with a 4-point rating scale illustrated by four smiley-faces that were of four different sizes (from smaller to bigger), four different colour intensities (from lighter to stronger) and four different smile intensities (from softer to broader). The scale was presented as followed: 1 = not funny, 2 = just a little bit funny, 3 = funny, 4 = very funny. During the whole procedure, participants were videotaped with a webcam and an additional back-up camera. An experimenter was always present during the procedure, to make sure

that the program ran smoothly and that the participant was able to use it properly. However, the experimenter interacted as little as possible (usually not at all) with the participants during the experiment.

Because of the risk of in-person testing due to the pandemic, slight adaptations had to be made to the procedure for two participants who participated online. Therefore, they would be videotaped via Zoom and one experimenter would present the task on a Powerpoint (randomization of the videos was done beforehand). Since it was not possible for the participants to interact with the experiment alone, they would orally respond to the questions. In both cases (one TD child and one adult with WS), their mother would start the Zoom meeting, check that the sound and image were good enough for the child, and then leave the room in order not to influence their child's responses.

2.3 Measures

Subjective ratings of amusement were calculated per group (ASD, DS, WS), ranging from a mean score between 1 (no funniness) and 4 (high funniness).

The expressions of mirth were coded with the program ELAN which allows a precise evaluation of their duration and the time they occur. Since participants had a tendency to laugh or smile also *after* the video was presented, the occurrences of smiles and laughs were coded for each stimulus from the moment the video started (after the fixation cross) until the end of the participant's amusement evaluation (when the next fixation cross appeared). Smiles or laughs occurring at the beginning of a stimulus that were obviously the continuity of a reaction to the stimulus before were not coded: Only *new* laughs and smiles were taken into consideration. In addition, smiles and laughs that were clearly directed at the experimenter or someone else in the room rather than in relation to the stimuli, were not considered in the analysis.

Smiling and laughter were defined based on Ekman's facial action coding system (FACS, Ekman & Friesen 1978) which distinguishes between different action units (AUs) that are related to the activation of specific facial muscles. A smile was operationalised as follows: The corners of the lips (AU12, *Zygomatic Major*) make an upward movement and there is also an activation of AU6 (cheek raiser, *Orbicularis oculi, pars orbitalis*). Smiles could be of intensity 1 or 2: For a smile of intensity 1, it was specified that the participant expresses a slight smile, that the corners of the lips make a slight upwards movement, and that the activation of AU6 can be very slight. For a smile of intensity 2, it was specified that the participant expresses a medium or large smile and that the corners of the lips make a

noticeable movement up. In addition, it was specified that an occurrence should start when the smile starts until it completely stops, even if there are intensity variations during the smile (the peak intensity of each occurrence counts).

A laugh was operationalised as follows: The slight laugh (intensity 1) is an extension of a slight/medium smile that is always accompanied by a sound, which can be either a puff (sound exhalation) from the nose or accompanied by a vocal sound (“hm”, “ha”), or seen by a movement of the shoulder. The slight laugh is often rather short. The medium/high laugh (intensity 2) is an extension of a medium/large smile that is always accompanied by a vocal sound (“hm”, “ha”). The laugh is often longer and generally ends with an inhalation (after the last laughing exhilaration). It was also specified that an occurrence should start when the laugh starts until it completely stops, even if there are intensity variations during the smile (the peak intensity of each occurrence counts).

It is important to note that the coding process was *inspired* by FACS, but as we were looking only at one specific emotional behaviour, a complete FACS coding and analysis were not conducted in this study by FACS trained coders. Instead, the specific AUs were used in the *description* of what is considered a smile or a laugh, to make the coders aware of what can be considered as a genuine smile or laugh (to reject occurrences of phony smiles or laughs related to discomfort, for example). However, the coders did not code the AUs separately. As such, all the analysis was based on the occurrence of smiles and laughs with respect to their global duration and level of intensity. Studies focusing on smiling and laughing behaviours in a specific population such as autism have typically not defined precisely what was considered as a smile or a laugh (Filliter et al., 2015; Reddy et al., 2002; Weiss et al., 2013). As such, this study has a more precise and replicable coding system, although not as precise as a complete FACS coding.

Traditionally, the analysis of expressions of mirth relies on three levels of observation: frequency (number of occurrences), intensity, and duration, although most research on such expressions in autism, typically, have focused on frequency and duration (Filliter et al., 2015; Reddy et al., 2002; Stagg et al., 2014; Weiss et al., 2013). In the present study, we focused on the analysis of intensity and duration, and not frequency, because it was necessary to be selective in the number of variables analysed, considering our small sample size. Conducting analysis for the three levels of observation in two small groups would have increased the family-wise error rate of the analysis. Considering that these three levels investigate different components of the same behaviour, it means that no relevant behavioural response was set aside, but a choice was made in the approach angles. The same line of thought underlay our

choice of the number of intensity levels that were coded and analyzed, which is not as precise as the five levels defined by Ekman et al. (2002). The reason for this less granular scale is that, due to the small number of participants, a more refined scale would substantially complexify the analysis, making the number of variables too high to reach a reliable group-comparison analysis.

Twelve recordings of the participants (6 WS, 6 TD), which accounts for 70.59% of all recordings, were randomly selected and coded in their entirety (all conditions included) by a second rater in addition to the main rater, to ensure the reliability of the coding system. Rosenberg and Ekman (1994, 2020) suggested using the following formula to calculate a ratio of reliability between two raters' coding, based on a second-by-second coding (Wexler, 1972): the number of occurrences on which both coders agreed multiplied by 2, and then divided by the total number of both coders' occurrences. This formula allows a more refined and appropriate interrater reliability measure, because it focuses only on the actual occurrences of the investigated behaviours (i.e., smile = 1, smile = 2, laughter = 1, and laughter = 2) and does not consider the neutral passages (i.e, smile = 0, and laughter = 0). Based on this formula, an interrater reliability reached an overall substantial strength (Landis & Koch, 1977) for both smiles (.733) and laughter (.746). The coding of the main rater was kept for further analysis.

2.4 Data analyses

The duration of smiles and laughs was calculated as a percentage of the total time of each stimulus (from the end of the fixation cross to the end of the evaluation process) since some participants would watch the video a second time, and due to the high variability of time participants took to rate each video. As such, for each stimulus, a percentage of the time spent laughing or smiling at different intensities was calculated, based on which, for each participant, a mean duration of smiles and laughs (of intensities 1 and 2), per condition (humorous and non-humorous) was calculated. The analysis was also run with the mean raw durations (measured in seconds, not proportional to the total time), but since there was no difference in the resulting effects with the measures in percentage, these data were then not reported in the results section. Additionally, for each participant and stimulus, the maximum intensity (0, 1 or 2) of smiling and laughter was noted. Furthermore, the mean level of maximum intensity was calculated for each group and each condition.

Considering that the duration is implicitly part of the definition of laughter in the coding process, as explained in the previous section, intensity of laughter also partly covers the duration in our study. As such, it should be kept in mind that the different behaviours analysed

are not completely independent, but rather, they measure different aspects of a similar phenomenon and can influence each other. This can have an important impact on the results of the analyses of these specific behavioural responses, and interpretation of the results should be done cautiously.

Considering the small sample size and confirmation by additional tests that normality could not be reached for all variables, non-parametric tests were run to compare the means between the different conditions (humour and non-humour), groups (WS and TD) and levels of coding (smile and laughs, intensities 1 and 2). Within group comparisons of means were executed using Wilcoxon signed ranked tests, and between groups comparisons of means were run with Mann-Whitney U tests. To overcome possible false positive results due to multiple testing, Holm-Bonferroni alpha corrections were applied (Hemmerich, 2016; Hochberg, 1988; Holm, 1979), to correct each p-value. The correction was applied for each step of the analyses separately: i.e., for amusement rating within groups, the correction was applied based on three p-values for the within groups and two p-values for the between groups analyses. For smile and laughter intensities, the corrections were applied for three p-values in the within groups and two p-values in the between groups analyses; for smile and laughter durations, the corrections were applied for nine p-values in the within groups and six p-values in the between groups analyses.

3 Results

3.1 Amusement Ratings

When both groups were considered together, a significant difference in the ratings of the humorous and non-humorous conditions appeared, $z = -3.46$, $p = .003$, $r = -.59$. This difference in the ratings of both conditions was confirmed when the groups were considered separately. The WS group rated the humorous condition as funnier than the non-humorous condition, $z = -2.52$, $p = .024$, $r = .63$, as did the TD group, $z = -2.37$, $p = .024$, $r = -56$. These results confirm the quality of the videos selected for both conditions and the ability of both groups to differentiate between humorous and non-humorous content. See the descriptive data in Table 1.

No significant differences in the amusement rating of the humorous content ($U = 21.5$, $z = -1.4$, $p = .322$, $r = -0.34$) or of the non-humorous content ($U = 31$, $z = -0.49$, $p = .628$, $r = -.46$) were revealed between individuals with WS and TD individuals. See the descriptive data in Table 1.

3.2 Smile intensity

A significant difference appeared in the maximum intensity of smiling (0–2) between the humorous and the non-humorous conditions when both groups are considered together ($z = -3.63$, $p < .001$, $r = -.88$), as well as individually in the WS group ($z = -2.54$, $p = .016$, $r = -.89$), and the TD group ($z = -2.67$, $p = .016$, $r = -.89$). These results show that the humorous condition triggered more intense smiles than the non-humorous condition in both groups. See the descriptive data in Table 1.

When looking at the mean maximum intensity of smiling (0-2) in each condition, results showed no significant group differences in the humorous condition ($U = 31$, $z = -0.48$, $p > .999$, $r = -.12$) or in the non-humorous condition ($U = 33.5$, $z = 0.24$, $p > .999$, $r = .06$), revealing no difference between individuals with WS and TD individuals in the maximum intensity of their smiles. See the descriptive data in Table 1.

3.3 Smile duration

When both groups were considered together, there was no significant difference between the conditions in the percentage of time participants displayed a smile of intensity 1 ($z = -1.97$, $p = .147$, $r = -.48$). However, there were significant differences in the percentage of time they displayed a smile of intensity 2 ($z = -3.48$, $p = .008$, $r = -.84$) and of both intensities considered ($z = -3.57$, $p = .003$, $r = -.87$). In the WS group, there were no significant difference between both conditions in the percentage of time they would display a smile of intensity 1 ($z = -1.26$, $p = .22$, $r = -.45$), of intensity 2 ($z = -2.38$, $p = .077$, $r = -0.84$) and of both intensities considered together ($z = -2.52$, $p = .077$, $r = -.89$). Similarly, the TD group displayed no significant difference between conditions in the percentage of time they would express a smile of intensity 1 ($z = -1.6$, $p = .22$, $r = -.54$), of intensity 2 ($z = -2.55$, $p = .077$, $r = -.85$) and of intensities 1 and 2 together ($z = -2.55$, $p = .077$, $r = -.85$). These results show that neither individuals with WS nor TD individuals showed a difference in the duration of their smiles of any intensity between the humorous than the non-humorous condition. See the descriptive data in Table 1.

For the humorous condition, no significant difference was revealed between individuals with WS and TD individuals in the percentage of time they displayed a smile of intensity 1 ($U = 34$, $z = -0.19$, $p > .999$, $r = -.05$), of intensity 2 ($U = 16$, $z = -1.93$, $p = .324$, $r = -.47$) or of both intensities combined ($U = 22$, $z = -1.347$, $p = .89$, $r = -.33$). For the non-humorous condition, results also revealed no significant difference between individuals with WS and TD individuals in the percentage of time they displayed a smile of intensity 1 ($U = 28$,

$z = -0.77$, $p > .999$, $r = -.19$), of intensity 2 ($U = 33$, $z = -0.29$, $p > .999$, $r = -.07$) or of both intensities combined ($U = 29$, $z = -0.67$, $p > .999$, $r = -.16$). As such, it appears that in both conditions, there is no difference in the duration of smiling between individuals with WS and TD individuals. See the descriptive data in Table 1.

3.4 Laughter intensity

When both groups are considered, there was a significant difference between the humorous condition and the non-humorous condition in the maximum intensity of laughter ($z = -3.12$, $p = .006$, $r = -.76$). Similarly, significant differences appeared in the WS group ($z = -2.37$, $p = .036$, $r = -.84$) and the TD group ($z = -2.01$, $p = .044$, $r = -.67$). These results show that for all participants, the humorous condition triggered laughs of a higher intensity for the humorous than the non-humorous condition. See the descriptive data in Table 1.

There were no significant group differences in the maximum intensity of the laughs for the humorous condition ($U = 13.5$, $z = -2.19$, $p = .058$, $r = -.53$) or the non-humorous condition ($U = 32$, $z = -0.42$, $p = .675$, $r = -.1$). These results suggest that the maximum level of intensity of laughter appeared to be similar in individuals with WS and TD individuals. See the descriptive data in Table 1.

3.5 Laughter duration

When both groups are considered together, there were significant differences between the conditions in the percentage of time they would display a laugh of intensity 2 ($z = -2.93$, $p = .027$, $r = -.71$), and of both intensities considered ($z = -2.98$, $p = .027$, $r = -.72$), but there was no such difference for the percentage of laughs of intensity 1 ($z = -1.92$, $p = .275$, $r = -.47$). For the WS group, however, no difference appeared between the humorous and non-humorous conditions for the percentage of laughs of intensity 1 ($z = -1.52$, $p = .384$, $r = -.54$), of intensity 2 ($z = -2.37$, $p = .108$, $r = -.84$), and of both intensities ($z = -2.52$, $p = .084$, $r = -.89$). For the TD group, there were also no significant differences between the humorous and the non-humorous condition in any of the measures of laughter; the percentage of time they would express a laugh of intensity 1 ($z = -1.15$, $p = .498$, $r = -.39$), of intensity 2 ($z = -1.83$, $p = .275$, $r = -.61$), or of both intensities together ($z = -1.15$, $p = .498$, $r = -.39$). These results suggest that neither individuals with WS nor TD individuals displayed a difference in the duration of their laughs between the humorous and the non-humorous conditions. However, when both groups were considered (i.e., independently of groups), individuals seemed to laugh longer and more intensively in response to humorous stimuli compared to non-humorous stimuli. See the descriptive data in Table 1.

For the humorous condition, a significant difference was found in the percentage of time individuals with WS and TD individuals express laughs of intensity 2 ($U = 7.5$, $z = -2.8$, $p = .03$, $r = -.68$). A significant effect was also found when looking at the percentage of time both groups would express laughs of both intensities combined ($U = 8$, $z = -2.71$, $p = .035$, $r = -.66$). However, no significant effect was found between both groups in expressing laughs of intensity 1 ($U = 33$, $z = -0.29$, $p > .999$, $r = -.07$). For the non-humorous condition, no significant difference was found between the two groups in displaying laughs of intensity 1 ($U = 34.5$, $z = -0.15$, $p > .999$, $r = -.04$), of intensity 2 ($U = 36$, $z = 0$, $p > .999$, $r = 0$), or both intensities combined ($U = 32.5$, $z = -0.36$, $p > .999$, $r = -.09$). These results suggest that individuals with WS express longer and more intense laughs than TD individuals in response to humorous stimuli, but this difference does not appear in the non-humorous condition. See the descriptive data in Table 1.

Table 1

Mean scores of measures of subjective rating, laughter, and smiling, per group

	All (*n* = 17)		WS (*n* = 8)		TD (*n* = 9)	
	M (SD)	***Mdn***	***M (SD)***	***Mdn***	***M (SD)***	***Mdn***
Mean amusement ratings, on a scale from 1 to 4, per condition						
Humorous condition	2.89 (0.79)	3.2	2.69 (0.6)	2.75	3.07 (0.92)	3.5
Non-humorous condition	1.82 (0.81)	1.4	1.63 (0.5)	1.4	1.99 (1.01)	1.5
Mean maximum level of smile intensity (0 – 2) reached per condition.						
Humorous condition	1.46 (0.47)	1.5	1.49 (0.57)	1.6	1.43 (0.4)	1.5
Non-humorous condition	0.72 (0.47)	0.7	0.73 (0.55)	0.55	0.72 (0.41)	1.5
Mean percentage of time smiles from different intensities were displayed per condition						
Humorous condition						
Smile 1	11.55 (8.97)	10.71	9.26 (5.29)	10.68	13.59 (11.25)	10.71
Smile 2	24.53 (16.18)	21.28	32.64 (16.12)	35.42	17.33 (13.13)	13.82
Smile 1 & 2	36.09 (15.19)	36.89	41.9 (16.16)	45.17	30.92 (12.99)	27.36
Non-humorous condition						
Smile 1	6.95 (6.15)	10.71	5.52 (4.68)	3.64	8.22 (7.25)	6.79
Smile 2	5.76 (6.88)	21.28	5.68 (7.2)	2.79	5.82 (7.02)	3.64
Smile 1 & 2	12.7 (10.73)	36.89	11.21 (11.62)	5.91	14.03 (10.38)	14.69
Mean maximum level of laughter intensity (0 – 2) reached per condition						
Humorous condition	0.76 (0.62)	0.8	1.09 (0.55)	0.9	0.47 (0.55)	0.3
Non-humorous condition	0.14 (0.23)	0	0.188 (0.3)	0.05	0.1 (0.15)	0
Mean percentage of time laughs from different intensities were displayed per condition						
Humorous condition						
Laughter 1	1.88 (2.17)	0.73	1.64 (1.97)	0.8	2.09 (2.44)	0.6
Laughter 2	7.35 (8.9)	2.27	13.92 (8.77)	14.31	1.52 (3.09)	0
Laughter 1 & 2	9.23 (9.03)	5.78	15.56 (8.37)	14.95	3.6 (5.13)	0.6
Non-humorous condition						
Laughter 1	0.88 (1.84)	0.27	0.38 (0.44)	0.29	1.32 (2.47)	0
Laughter 2	0.1 (0.3)	0	0.06 (0.18)	0	0.13 (0.39)	0
Laughter 1 & 2	0.98 (1.98)	0.27	0.45 (0.47)	0.38	1.45 (2.66)	0

Note: *WS* Williams syndrome, *TD* typically developing; *All* both groups considered together.

4 Discussion

The present exploratory study examined (1) basic humour processing skills, and (2) expressive responses (smiles and laughs) to simple humorous and non-humorous stimuli in individuals with WS. These were compared to mental age-matched typically developing children.

Humour processing skills

Results suggest that, on average, individuals with WS appreciate simple types of humour in much the same way as TD individuals. Indeed, both groups evaluated the humorous condition as more amusing than the non-humorous condition. We have expected that the positivity bias common in individuals with WS (Järvinen et al., 2013) might prevent them from adequately differentiating between humorous and non-humorous stimuli, but they showed a clear ability to distinguish between the conditions and to report their level of amusement accordingly. These results suggest that even if individuals with WS experience more positive emotions generally, they do not do so unconditionally and indiscriminately, at least with respect to non-socially shared humour. Such findings add to our comprehension of the cognitive abilities of individuals with WS: Despite their intellectual disabilities, it seems that individuals with WS have the cognitive flexibility necessary to successfully achieve incongruity resolution involved in the comprehension of humour (Ruch, 2008; Suls, 1972). While previous studies highlighted the difficulties individuals with WS have with complex conceptual representations involved in some types of humour, such as ToM or inferential reasoning (Godbee & Porter, 2013; Krishan et al., 2017; Sullivan et al., 2003), the present study shows that they understand humour in much the same way as TD individuals when it is non-verbal and simple.

Expressive responses

The fact that a positivity bias appears to influence the attention and appraisal of social stimuli in individuals with WS has been widely described: it is mainly marked by comparatively high approachability, hypersociability (Jones et al., 2000), a lower sensitivity for negative socio-emotional information (Mervis & John, 2010). This bias also reveals itself with respect to positive faces, in that individuals with WS show a greater amount of attention to happy faces than chronological and mental age-matched groups do (Dodd & Porter, 2010). However, to date and to our knowledge, no study has investigated their expressive responses to positive and neutral stimuli. The present study adds to the understanding of their particular social and emotional profile since it suggests that individuals with WS also display a

particularly high level of expressivity in response to positive stimuli, compared to TD individuals. In both groups, the maximum intensity of smiles and laughs were higher in the humorous than in the non-humorous conditions, but no group differences appeared. Moreover, both groups did not differ in the duration of the smiles they displayed, and none of them generally expressed longer smiles or laughs in one condition compared to the other. However, individuals with WS expressed laughs of a higher duration than the TD comparison group, but only for the humorous condition. In other words, in response to amusing stimuli, individuals with WS would more easily laugh out loud for a longer time than TD individuals. When considering laughter as an expression of positive emotions of a higher intensity than smiling, these results suggest that individuals with WS differ from mental age-matched TD children in terms of the intensity of expressions of positivity.

Individuals with WS have been described as having difficulties with response inhibition, i.e. the ability to restrain a spontaneous response (Greer et al., 2013; Little et al., 2013; Menghini et al., 2010). This seems to be related to individuals with WS' higher promptness to approach others, including strangers (Mervis & Klein-Tasman 2000, Little et al., 2013), as well as to their lower tendency to inhibit their expressive responses to regulate their emotions (Samson et al., 2022). The lower tendency to inhibit spontaneous responses might drive individuals with WS to be less concerned that TD individuals about laughing loudly in the presence of others, even if the laughter is not socially shared as it usually is (Provine, 2017, Reddy et al., 2002). In general, the present results might be a first exploratory step to actually confirm that individuals with WS smile and laugh more than their TD counterparts, even in contexts that seem less appropriate. However, this should be investigated further in order to reach clearer conclusions.

Limitations and Future Research

Future studies should more thoroughly investigate the comprehension and appreciation of different types of jokes in individuals with WS, including the underlying cognitive processes, to build on what is currently known about the understanding and appreciation of humour and the cognitive profile of individuals with WS (see for example the study of Samson & Hegenloh, 2010) .

The expressive responses of individuals with WS to different positive emotions (such as love, awe, or pride) should be examined to evaluate whether the tendency of their positivity bias to heighten their expressive responses to positive stimuli can be generalised. Moreover, to investigate whether the increased expressive response is syndrome-specific, future studies should investigate the phenomenon in individuals with Down syndrome, who present

a similar socio-emotional phenotype (they are also described as hypersociable and particularly cheerful (Grieco et al., 2015; Porter et al., 2007). Moreover, exploring developmental trajectories in TD individuals would ascertain whether a similar expressive response could be present in younger or older TD children, to further explore whether this is really a particularity of WS.

In order to better appreciate the extent to which individuals with WS really engage equally and more easily in socially shared and non-shared laughter, future studies should investigate their expressive response in completely solitary situations (without the presence of an experimenter), as well as in more ecological settings, including the (spontaneous and controlled) interaction with and the expressive response of another person.

Such knowledge about individuals with WS' tendency to show an increased emotional response to positive stimuli would add new information on their particular socio-emotional profiles, which is necessary to build socio-educative programs to help them regulate their emotions and interact in the social world. Indeed, individuals with WS have been described as having difficulties in sustaining long-term friendships, due notably to particular maladaptive and inadequate behaviours as well as emotion regulation difficulties (Gillooly et al., 2022; Samson et al., 2022). Interventions aiming at increasing their abilities to regulate (in this case, *inhibit*) their emotional responses might help them to develop more adapted social behaviours and in turn build more durable relationships.

Laughter and smiling can have various meanings and are not only a behavioural manifestation of positive emotions. Indeed, not only can they have different functions in terms of social interaction (Wood & Niedenthal, 2018), but they can also be a manifestation of other emotions, such as embarrassment, contempt, or fear (Ruch, 2008). As such, it would be unjustified to infer from the present analysis that individuals with WS experience more positive emotions because they seem to laugh more. Some of their smiling and laughing behaviour in their daily lives is likely to be related to trying to initiate or sustain a social interaction, or even to mask negative emotions. Indeed, Sinason (1992) introduced what she called the "handicapped smile", by explaining how individuals with intellectual disabilities' smiles are often misinterpreted as being related to their supposed positive emotions, whereas they often smile as a defence mechanism against negative experiences (see also Lloyd, 2018). Nevertheless, the present study focuses on smiles and laughs as responses to humorous stimuli. Considering the design of this study, it seems highly likely that the positive expressivity of individuals with WS is related to spontaneous amusement rather than anything else, such as masking a negative emotion. Future studies should however investigate

different types of laughter in individuals with WS to better grasp the nature of their potential higher tendency to engage in smiling and laughing.

In spite of the explicitly exploratory nature of this study, it is important to highlight four important limitations. First and foremost, due to the rarity of WS, the sample size is small: Results thus have to be read and interpreted carefully. Second, the current study does not include a chronological age-matched control group, but only a mental age-matched one. Previous studies on more cognitively demanding humour in WS often showed differences with the chronological age-matched group but not the mental age-matched group, which can be interpreted as them showing a delay rather than a differentiated cognitive pathway. However, the inclusion of, for example, TD adults seemed likely to be less informative here, given that the video clips are taken from movies made for children. Third, the setting of the present study is partially social, since an experimenter was always present, but only to make sure the session went as planned. Although during the task the participants were almost exclusively interacting with a computer, the setting does not allow us to make conclusions about individuals with WS' strictly solitary laughter. Further study should consider exploring the participants' expressions with and without the presence of an experimenter in order to better understand the influence of the presence of another person on their expressivity. In the present analysis, the laughs and smiles that seemed to be directed to another person were not considered, as they were deemed social rather than solitary laughter. Fourth, while the coding system we used is more precise than previous studies, the coding system of the facial expressions would have been even more reliable and would have allowed more refined data analyses if proper FACS (Rosenberg & Ekman, 1994, 2020) coding was used. Another limitation of our coding system, though, is that our definitions of smiles and laughs on which the coding was based are somewhat intertwined. When it comes to responding to humorous stimuli, smiles and laughs are different manifestations of a similar emotional experience and are thus logically connected to one another. However, having AU12 and AU6 coded separately with more levels of intensity (Ekman et al., 2002) would have allowed to better define laughs and smiles intensities and to avoid to use duration as a part of the definition in laughter intensity. Given the small number of participants and the exploratory nature of this study, it was deemed appropriate to proceed in this manner. Nonetheless, interpretation should thus be done cautiously and future studies should implement a more refined coding system such as FACS. However, as mentioned above, one strong element of our coding system is that it still includes a precise and developed definition of what is considered a smile or a laugh, which is sufficiently developed to allow the study to be replicable.

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Conflict of Interest

The authors report there are no competing interests to declare.

Ethics statement

This study was approved by the Swiss Ethical Committee Board of Geneva (No.2017-01435).

Informed Consent

For all participants, an informed consent was received including the signature of the participants and their parents.

Author Contributions

NT: conceptualisation, methodology, investigation, data curation, project administration, visualisation, writing – original draft. DD: conceptualisation, writing – review & editing. KB: resources, writing – review & editing. AS: conceptualisation, methodology, project administration, supervision, funding acquisition, writing – review & editing.

Data Availability

All data are available at the Open Science Framework: https://osf.io/k764t/

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3 General discussion and conclusion

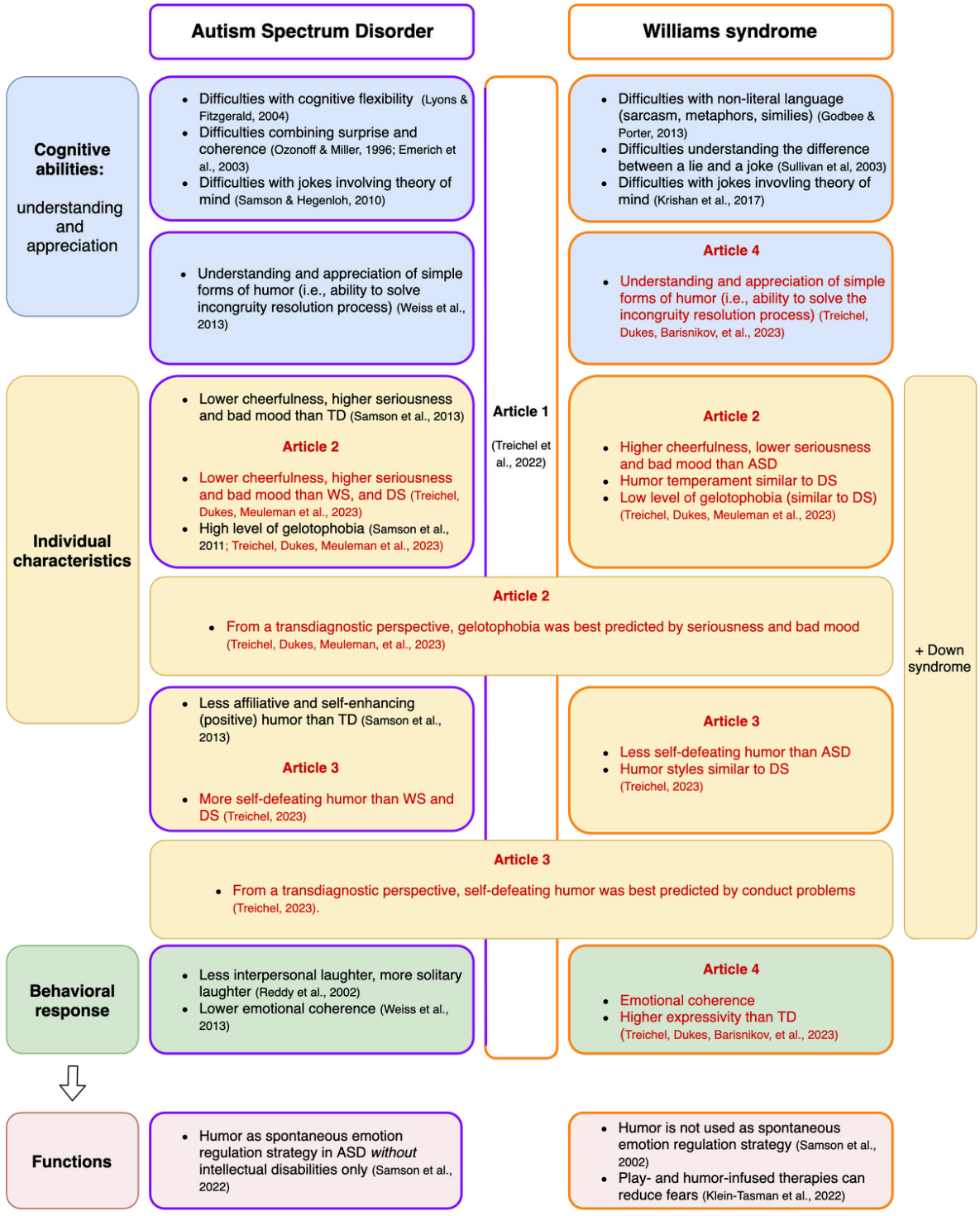
Considering the importance of humor in everyday human communication and its impact (positive and negative) on psychological well-being, the goal of this thesis is to better understand the specificities of humor of individuals with neurodevelopmental conditions, namely ASD and WS. The different articles presented in this thesis are articulated around three domains of humor: cognitive abilities, individual characteristics, and the behavioral response. This last chapter of the thesis first summarizes the main findings and describes what they add to the ongoing knowledge base on humor in autism and WS. It then addresses the practical and conceptual implications of these findings and suggests some avenues for future studies. Finally, this chapter addresses both the limitations and strengths of the studies that constitute this thesis.

3.1 Overview of the main findings

As presented in the Introduction chapter, research had already been conducted on humor in individuals with ASD and provides a first insight into autistic individuals' humor profile in light of their cognitive abilities, individual characteristics, and behavioral responses. Based on these studies, this thesis aimed to (1) investigate whether some of the results concerning specificities observed in autistic individuals could be replicated, and (2) contribute to building a more refined humor profile of individuals with WS. Figure 1 provides an updated overview of the findings of previous research and those of the research presented in this thesis regarding the cognitive abilities, individual characteristics, and behavioral responses related to humor in individuals with ASD and WS.

Figure 1

State of the art (updated): Overview and comparison of how humor in ASD and WS is currently understood in the scientific literature and of the main findings of the thesis (in red).



Note: *ASD*, autism spectrum disorder; *DS*, Down syndrome; *TD*, typically developing; *WS*, Williams syndrome.

3.1.1 Humor in individuals with autism spectrum disorder: Advancing current knowledge

Previous research on humor in ASD has investigated all the three humor domains that are articulated in this thesis (i.e., cognitive competencies, individual characteristics, and behavioral responses). I did not investigate further the *cognitive competencies* and *behavioral responses* of autistic individuals, for which the main findings are presented in the introductory chapter. These findings are informative, and they helped us to build our research investigating the cognitive competencies and behavioral responses of individuals with WS in relation to humor. However, two articles in this thesis (Articles 2 and 3) focused on *individual characteristics* that have been previously explored in individuals with ASD, and their main results are presented and discussed in this chapter.

Individual characteristics

The goal of Article 2 was to investigate whether the high prevalence of gelotophobia previously observed in autistic individuals (Samson et al., 2011; Tsai et al., 2018) can also be observed in a younger and more cognitively diverse population of autistic individuals, and whether elevated levels of gelotophobia are specific to autistic individuals or whether gelotophobia is also elevated in individuals with other neurodevelopmental conditions, namely WS and DS. The results confirmed the high prevalence of gelotophobia only in autistic individuals. Indeed, whereas previous research has already highlighted that autistic individuals present a high level of gelotophobia compared to the TD population (Samson et al., 2011; Tsai et al., 2018), the present research is the first to demonstrate that this specificity of individuals with ASD is maintained when compared to other neurodevelopmental conditions, namely WS and DS. Such a finding is of great importance to grasp a deeper understanding of autistic individuals' perceptions of humor and laughter. Indeed, whereas humor and laughter can have a considerable positive impact on well-being when they are positively intended and understood, they can also have a damaging impact on an individual's ability to grow in the social world, especially when they appear as a source of anxiety, as seems to be the case for an important number of individuals with ASD. Our findings demonstrate that the temperament of autistic individuals towards humor, in that they tend to be rather serious and more frequently in a bad mood, is related to higher gelotophobia. Moreover, these characteristics seem to be better predictors of gelotophobia than the condition itself. As such, in Article 2, we explain that it is because of their more serious

temperament that individuals with ASD tend to misinterpret laughter as being directed toward themselves.

What is yet to be examined is where this temperament finds its origins. What is the source of such a serious way of perceiving the world? One hypothesis might be that it is related to the weak central coherence hypothesis (Happé, 1997; Lyons & Fitzgerald, 2004), which states that autistic individuals tend to have difficulties getting the "big picture," and instead, they focus on details, although, as presented in the Introduction, the weak central coherence hypothesis has been questioned and nuanced in more recent studies, notably highlighting the importance of the dimension measured by different stimuli. A more recent approach to understanding a similar cognitive mechanism is the Bayesian approach (Haker et al., 2016; Palmer et al., 2017; Pellicano & Burr, 2012). Briefly, the Bayesian approach suggests that autistic individuals present with "hypo-priors," in that they tend to rely less on prior knowledge to interpret a situation (Pellicano & Burr, 2012). In other words, their "perception (and other neural processes) are dictated to a greater extent by the present sensory data rather than prior or contextual information" (Palmer et al., 2017, p. 1). This, it has been argued, leads them to see the world more accurately, in the sense that they perceive events and their characteristics in the moment, and not based on prior experiences (we might say they are over-unbiased). In other words, autistic individuals might perceive the world as "too real" (Pellicano & Burr, 2012). "This results in percepts that are dominated by sensory inputs and less guided by top-down regularization and shifts the perceptual focus to detailed aspects of the environment with difficulties in extracting meaning" (Haker et al., 2016, p. 1). However, being able to be in a humorous state of mind requires the ability to overcome the simple pragmatic interpretation of events, and to be able to switch from one mental representation to another based on prior knowledge and experiences. As such, it is understandable that, if autistic individuals process their environment in a more Bayesian way, they will have a reduced tendency to be in a humorous mood or appraise the event around them humorously.

To understand that a laugh can be directed towards many things other than themself, a person has to refer to previous experiences where laughter was obviously not directed toward them. Interestingly, previous research had also highlighted the particular laughing behavior of individuals with ASD, who do not necessarily laugh as a response to humorous events (Weiss et al., 2013) and also do not necessarily need to share their laughter with others (Hudenko & Magenheimer, 2012; Reddy et al., 2002). As such, it might be that in their perception of the world, laughter is not necessarily a behavior that is shared with others, and

thus, it is not evident to them that when somebody laughs *with* them, they are not laughing *at* them. This should definitely be investigated further, as the possible interpretation suggested here is only a hypothesis. A more refined understanding of the source of gelotophobia in individuals with ASD is thus needed, notably because it has been shown that being a victim of bullying is a predictive factor for the development of gelotophobia (Leader et al., 2018; Platt et al., 2009; Ruch et al., 2014), and that autistic individuals report important incidences of being bullied (Cappadocia et al., 2012; van Roekel et al., 2010) that are more frequent that in individuals with or without other neurodevelopmental conditions (Kloosterman et al., 2013). It might be that, if they can improve their understanding of others' laughter, individuals with ASD might experience a slightly lower level of bullying, at least in cases where these phenomena intertwine. Having said this, it is evident that bullying experiences do not rely only on the victims' perceptions; therefore, interventions should mainly focus on the bullies. However, understanding autistic individuals' interpretation of others' laughter might, in some cases, be a tool to help them distance themselves slightly from perceived mockery. These findings thus call for particular attention towards autistic individuals' interpretation of laughter, to detect potential anxiety that is related to it and be able to intervene when necessary. Moreover, such findings also suggest that we should be particularly attentive when interacting with autistic individuals, who might not interpret daily humor and laughter as being as positive as could be intended.

Articles 2 and 3 aimed to expand our knowledge on autistic individuals' temperament towards humor and their more frequently used humor styles, to contribute toward drawing a general and typical humor profile of autistic individuals. As mentioned above, the results of Article 2 revealed that individuals with ASD appear to be less cheerful, more serious, and more likely to be in a bad mood than individuals with DS and WS, compared to TD individuals, as previous research has also demonstrated (Samson et al., 2013). The results of Article 3 suggest that autistic individuals also more frequently use self-defeating humor than individuals with WS or DS. These findings seem consistent with one another and coherent in terms of the literature. Indeed, autistic individuals' frequent use of self-defeating humor together with their higher seriousness and bad mood (i.e., higher levels of ill-humor) probably intertwine and represent a general relatively negative temperament in relation to humor.

At first sight, these interpretations seem to imply that autistic individuals present with less interest in producing or appreciating humor, seemingly rendering the argument in favor of Asperger's (1944) claim that they lack a sense of humor. However, I would like to emphasize that it is not my intention to suggest that autistic individuals lack a sense of humor,

but rather to underline that, as mentioned in the Introduction chapter, they might have a sense of humor that does not necessarily rely on the components of what we conceive as a normative sense of humor. Indeed, autistic individuals might be amused by other things compared to TD individuals. Future research should therefore investigate more thoroughly what type of humor autistic individuals tend to engage in and appreciate. This being said, it also seems important to acknowledge that some individuals might not benefit from humor as much as is normatively imagined, and this should not necessarily be seen as a deficit. Indeed, if autistic individuals get less out of humorous interactions for the reasons outlined above, it seems logical that they simply engage less in humor. As such, while I will later suggest several practical implications of this research, which include possible interventions to reinforce the ability to use humor to increase personal well-being, I also want to point out that it should be accepted that some individuals do not need or even want to engage in humor so much. This, however, does not concern only autistic individuals; nevertheless, they seem to be especially affected by this specific humor temperament. Thus, interventions in this area are not always pertinent. It seems particularly important to support individuals' specificities and not to assume that a lower use of humor is necessarily a deficit to be improved. However, special attention should be paid to autistic individuals' tendency to develop an anxious fear of being laughed at, which has important consequences for their social lives and well-being.

3.1.2 Humor in individuals with Williams syndrome: Advancing current knowledge

To date, the few studies that have investigated humor in individuals with WS focused on their cognitive abilities to comprehend complex forms of humor. This area of research thus needed new input, and this began here, with an examination of the cognitive and socio-emotional profile of individuals with WS in relation to humor. This was, as presented above, one of the goals of this thesis, which brings new insight to our understanding of the specificities of the syndrome.

Cognitive abilities

Research has shown that individuals with WS tend to have difficulty understanding and appreciating complex types of humor, notably when they involve theory of mind or non-literal language (Godbee & Porter, 2013; Krishan et al., 2017; Sullivan et al., 2003). To better grasp the cognitive abilities of individuals with WS in relation to humor, Article 4 of this thesis investigated the appreciation of simple humor, i.e., non-verbal slapstick humor, which does not involve any of the high-demand cognitive abilities involved in more complex forms of humor. Our findings revealed that individuals with WS appreciate this type of humor in much

the same way as mentally age-matched TD participants. These results suggest that individuals with WS have the cognitive ability to solve the incongruity in the case of simple humor, thus validating my hypothesis that their mild to moderate intellectual disabilities do not prevent them from understanding *every* type of humor. Indeed, although they have been reported as having difficulties with different executive functions (Costanzo et al., 2013; Menghini et al., 2010), it appears that individuals with WS still have sufficient cognitive flexibility to solve the incongruity in simple types of humor.

Individual characteristics

Article 2 investigated whether individuals with WS experience high rates of gelotophobia, as reported by their caregivers. As expected, the results revealed that individuals with WS tend to experience quite low levels of gelotophobia; they show a lower rate of gelotophobia compared to individuals with ASD, and a similar rate compared to individuals with DS. As such, although there can still be isolated cases of gelotophobia in individuals with WS, this does not seem to be a general concern, which is also consistent with their tendency to develop non-social rather than social anxieties (Dykens, 2003). As described above, they seem to be protected from developing this fear of being laughed at, notably because of their cheerful temperament. In other words, in contrast to what has been observed in individuals with ASD, individuals with WS tend to comprehend their environment in a cheerful way and with a mindset open to humorous interpretations. This allows them to approach the laughter of other people rather positively.

Articles 2 and 3 also aimed at examining the humor temperament and preferred humor styles of individuals with WS, to better understand their general and typical humor profile. Individuals with WS were found to engage in less self-defeating humor than individuals with ASD, but at a similar rate to individuals with DS. These findings seem to be consistent with the humor profile of individuals with WS that has been drawn on their reported humor temperament. Indeed, their particularly high cheerfulness scores and low seriousness and bad mood scores suggest that individuals with WS tend to look on the bright side of life, be rather spontaneous, and not easily become grumpy. As such, it might be that they do not present with many instances or types of negative humor, either toward themselves or toward others, because they might not instantly see the "darker side of things." Overall, these findings are consistent with the general socio-emotional profile of individuals with WS depicted by research, which pictures them as being generally cheerful, in a good mood, and open to humorous interactions. Thus, these findings seem consistent with one another.

Indeed, the less frequent reported use of self-defeating humor in individuals with WS, together with their higher cheerfulness (i.e., higher levels of humor), probably intertwine and depict a general relatively positive temperament in relation to humor.

Behavioral response

In line with their general cheerfulness and hypersociability, individuals with WS have been described as smiling and laughing a lot. However, to date and to my knowledge, no studies had consistently investigated their facial expressions in relation to positive emotions such as mirth or amusement. As such, Article 4 investigated the behavioral response of individuals with WS to humorous stimuli, to elucidate whether they are indeed more expressive (i.e., whether they smile and laugh more than TD individuals). As expected, the results seem to suggest that they have a tendency to engage more in "extreme" behavioral responses (i.e., "laughing out loud"). Thus, in the case of amusement, individuals with WS seem to be particularly expressive, even when the humorous content is not directly socially shared. Contrary to our expectations, however, they seem to present with an emotional coherence, in the sense that they do not laugh independently of their subjective experience. In other words, they do not simply laugh all the time, irrespective of context. Indeed, they display smiles and laughs of a higher intensity in humorous rather than non-humorous conditions.

Although the research in Article 4 was exploratory, its results bring interesting and important new insights to our understanding of the typical behavior of individuals with WS. As such, it can be interpreted that, when it comes to amusement, their behavioral responses match their subjective experiences. However, a call for a careful interpretation of such a statement is necessary here. A common mistake would be to interpret every occurrence of smiling or laughter as being related to a positive state of mind or the experience of positive emotions. It is important to keep in mind that smiling and laughter play various roles in human interaction and communication. At times, they can even be related to more negative experiences or emotions, such as fear or embarrassment (Ruch, 2008). Thus, although the profile of individuals with WS seems to suggest that they are open to humor and are highly cheerful, it would be dangerous to assume that they are always happy and amused. It is important to acknowledge that they also experience high rates of anxiety (Royston et al., 2017). This being said, what these findings add is that, since individuals with WS seem so open to humor and are cognitively able to understand at least simple types of humor, humor-

based interventions might be an efficient way to help them deal with instances of fear and anxiety (see research by Klein-Tasman et al., 2022).

3.2 Theoretical and practical implications

3.2.1 What the findings add to our understanding of humor

As stated in the Introduction chapter and Article 1 of this thesis, studying humor in neurodevelopmental conditions also allows for a better understanding of humor itself. Indeed, ASD and WS seem to be two extreme poles of a social motivation spectrum, and thus, understanding differences in individuals who have these conditions can inform us about the influence of social motivation on humor processing per se. Moreover, considering that individuals with WS and ASD present with specific cognitive strengths and difficulties, investigating their understanding and appreciation of different types of humor can also bring insight into our understanding of the cognitive processes involved in humor comprehension and production, from a developmental perspective.

Our findings underline the importance of having an intrinsic social motivation to be eager to engage in humorous interactions. As a reminder, social motivation is described as a set of dispositions leading individuals to "preferentially orient to the social world (social orienting), to seek and take pleasure in social interactions (social reward), and to work to foster and maintain social bonds (social maintaining)" (Chevallier et al., 2012a, p. 231). Individuals with ASD, who have been reported to have low social motivation, have been described in various studies, as well as this thesis, as having low motivation to engage in humorous interactions (Chevallier et al., 2012a), being rather serious (Samson et al., 2013), producing less positive humor than TD individuals and more negative humor than individuals with WS and DS, and developing more anxiety in relation to laughter (Samson et al., 2011). On the other hand, individuals with WS, who show high social motivation (Gillooly, 2018), seem to be highly cheerful, and thus, are open to humorous interactions, express their amusement more expressively, use less self-defeating humor than individuals with ASD, and have little to no anxiety in relation to others' laughter (although, it has been shown that individuals with WS show high levels of auditory aversions, notably to the sound of laughter (Levitin et al., 2005), but these are related to a sensory processing of hyperacusis and not to a subjective experience of feeling ridiculed or mocked when faced to others' laughs). Interestingly, similar results are evident for individuals with DS, who are reported to have a socio-emotional profile comparable to individuals with WS. Indeed, individuals with DS are

also described as highly sociable (Grieco et al., 2015; Porter et al., 2007), and thus probably would feature near the top end of a social motivation spectrum, and the results of Articles 2 and 3 present them as displaying individual characteristics in relation to humor that are similar to individuals with WS. Considering that the social motivation spectrum is continuous, such findings can be extended to other individuals with or without neurodevelopmental conditions, and we suggest that the differences in motivation to engage in humor should be examined in light of the social motivation hypothesis. Such an association also highlights that social rewards do not have the same value and importance for all individuals, which partially explains why humor orientation varies so importantly from one person to the next. Thus, it seems that individuals who are more inclined to orient to the social world and who are more in need of social rewards will have a temperament that translates into a higher motivation to explicitly engage in humorous interactions and have a more positive relationship with humor.

From a developmental perspective, research on humor in neurodevelopmental conditions can bring new insight into the cognitive processes involved in specific types of humor. Research has notably highlighted the difficulties that both individuals with ASD and WS have with the comprehension of humor involving theory of mind (Krishan et al., 2017; Samson & Hegenloh, 2010). Such findings corroborate that, on the one side, individuals with WS and ASD have difficulty understanding jokes that are based on false belief (e.g., if one character in the joke is in a state of false belief, not knowing what the other characters know). On the other side, these findings highlight that these types of jokes necessitate specific socio-cognitive abilities that are known to develop throughout the lifespan (Wellman et al., 2001). In other words, this suggests that some types of humor can only be understood if and once these socio-cognitive abilities have been properly acquired. Past research and our findings have, however, highlighted that autistic individuals and those with WS are able to appreciate simple humor in much the same way as mentally age-matched TD individuals. Our findings show that understanding and appreciating humor does not necessarily involve high-demand socio-cognitive abilities, such as a theory of mind. As such, our studies on the comprehension and appreciation of humor in neurodevelopmental conditions confirm that humor does not necessarily involve the socio-cognitive processes of theory of mind, contrary to what some humor theories suggest (Howe, 2002), but that these processes are involved only in some specific types of jokes (Samson, 2012).

Finally, the research constituting this thesis tried to highlight the heterogeneity of individuals' relationships with humor. Indeed, although humor is, at first sight, perceived as a way of triggering positive emotions, it can also be a source of anxiety, as we demonstrated,

and consistent with the literature (Samson et al., 2011; Wu et al., 2015), that autistic individuals have a higher tendency to develop gelotophobia or use self-defeating humor. On the other hand, some individuals have socio-emotional profiles that seem to make them particularly open to humor and laughter, such as individuals with WS, who also present with difficulties understanding some types of humor and inhibiting their expressive reactions.

3.2.2 A transdiagnostic perspective

In recent years, the fields of psychology and psychiatry have developed a new approach to research and clinical practice—the transdiagnostic approach—in order to overcome the limitations of the diagnostic approach. Indeed, the classical diagnostic classification of psychopathological conditions, as it appears in the DSM-5-TR (APA, 2022), has been criticized, notably because it does not consider enough individual differences in terms of the actual manifestation of the different processes involved in each diagnosis, and also because of the important proportion of comorbidities (Fusar-Poli et al., 2019; Monestès & Baeyens, 2016). To respond to these issues, the transdiagnostic approach suggests that we rethink the categorization of mental health problems and psychiatric conditions by looking at "similarities in the processes responsible for the expression, origin, or maintenance of clinical signs observed in different disorders"[19] (Monestès & Baeyens, 2016, p. 2). The transdiagnostic approach suggests that we study psychiatric conditions and mental health problems in terms of the "etiological and maintenance processes, as well as cognitive, affective, interpersonal, and behavioral features" (Fusar-Poli et al., 2019, p. 192) that have been demonstrated as being common in various conditions. These characteristics are known as "transdiagnosis processes." Different categorizations have been proposed, including different transdiagnosis processes (for reviews, see Dalgleish et al., 2020; and Fusar-Poli et al., 2019). For example, it has recently been suggested that emotion regulation be added as a transdiagnostic process to existing categorizations (Cludius et al., 2020).

I will not go into the details of each of these categorizations but I wanted to point out that psychiatric conditions could (and probably should) be studied and understood in terms of the psychological processes involved. This new perspective might not only influence clinical practices, it can also change the prism through which research in special education,

[19] Translated from French to English by the author. Original version: "des ressemblances au niveau des processus responsables de l'expression, de l'origine ou du maintien des signes cliniques observés dans différents troubles" (Monestès & Baeyens, 2016, p. 2).

psychology, and psychiatry interpret their findings. Thus, in Articles 2 and 3, we interpreted the results from a transdiagnostic perspective. Indeed, our findings suggest that specific individual characteristics predict differences over and above the diagnoses themselves. Namely, a higher level of gelotophobia was better predicted by high seriousness and bad mood scores than by the diagnoses themselves, and differences in humor styles were better predicted by conduct problems than by the diagnoses themselves. In other words, it is not sufficient for clinical practice and research to depict the humor profile of individuals with specific neurodevelopmental conditions without investigating the source of potential particularities. As such, it seems that it is the psychological process of seeing the world in a serious and rather negative way that leads autistic individuals to develop a greater fear of being laughed at, and conduct problems seem to be at the origin of a more frequent use of self-defeating humor. With this in mind, our findings can be extended to other conditions, as well as to the TD population, in that individuals who tend to experience similar psychological processes (i.e., seriousness, bad mood, and conduct problems) might have similar consequences in their relation to humor.

3.2.3 Practical implications

So far, I have highlighted the conceptual applications of my research for the understanding of humor in general and in neurodevelopmental conditions. Such knowledge also has practical implications, and these are addressed in this section.

First, since humor seems to have such an important influence on individuals' well-being, it is logical to raise the question of whether humor can be increased through training. Several studies have demonstrated that humor can be trained to foster its use as a coping strategy, thus increasing individuals' well-being (for an overview, see Kuiper, 2012). Specifically, Crawford and Caltabiano (2011) showed that, in TD adults, humor training sessions can increase individuals' positive affect, optimism, self-efficacy, and perceptions of control, and decrease symptoms of depression, anxiety, and stress. Such intervention has also been proven to be effective for increasing the ability to use humor as a coping strategy in individuals that display major depression (Falkenberg et al., 2011) and schizophrenia (Cai et al., 2014). Importantly, Wu et al. (2016) demonstrated the effectiveness of humor training on autistic adolescents' ability to understand and appreciate nonsense humor, "which do[es] not require knowing the logic of the content or the mental state of the people involved in the joke" (p. 29). However, it did not increase their understanding of incongruity-resolution jokes. Despite this, the authors revealed that the autistic adolescents who took part in the training

sessions seemed to be more willing to use affiliative humor afterwards, suggesting that autistic individuals can learn to use humor as a mean of socialization and affiliation.

These findings on the efficacy of humor training for the general population and clinical cases are promising for the development of new interventions aimed at helping individuals to develop new emotion regulation strategies, in order to reduce their anxieties and experiences of negative emotions. To date and to my knowledge, no studies have investigated the efficacy and effectiveness of humor training to increase general psychological well-being in individuals with other neurodevelopmental conditions. Thus, this area of research and practice has yet to be developed. However, to be able to build adaptive and effective interventions, it is important to consider individual characteristics, such as differences in humor styles and humor temperament, and this is where this thesis becomes purposeful. Indeed, it seems that training programs for autistic individuals, for example, should articulate around fostering not only their ability to understand specific types of humor but also their general mindset and ways of perceiving their environment.

I raise two questions then: Does this really make sense? and Is this trying to change their personality rather than foster their abilities (which interventions aim to do)? Since autistic individuals seem to be rather serious and interpret laughter in a more negative way, it seems that focusing solely on their cognitive ability to process specific jokes would be ineffective just by itself, because the emotional response might not be the targeted one. Humor is not, as I describe above, only about cognitive abilities, but also about personal emotional profiles. Maybe then, although I recognize that this claim might be controversial, interventions aimed at increasing the use of humor in autistic individuals might make little sense, since these individuals have an emotional temperament that makes them less inclined to benefit from humor. It seems, considering their socio-emotional profile, that humor might not be the best coping strategy for autistic individuals, and interventions should probably focus on other dimensions. Again, this is not to say that autistic individuals lack a sense of humor, but it seems that they still show a reduced interest in engaging in humor compared to the normative perception of the importance of humor. These observations should perhaps be seen as valuable personality characteristics, rather than as deficits to intervene for. This being said, another important practical consideration arising from our results is that, considering that others' laughter seems to be a potential source of anxiety for autistic individuals, interventions should instead probably focus on helping them to reinterpret laughter. Such intervention, in contrast, would be highly relevant for autistic individuals and might help them develop in the social world and reduce some of their social anxieties.

In the case of individuals with WS, the reverse seems to apply. Indeed, unsurprisingly perhaps, our findings support their previously described cheerfulness. This means that individuals with WS seem to be particularly open to humor, which makes it a potentially strong tool to help them regulate their emotions and deal with the adversities of life. It should be noted, however, that a recent study has revealed no correlation between the use of humor as a coping strategy and the development of anxieties in individuals with WS (Samson et al., 2022). Thus, the use of humor as an emotion regulation strategy might be a great tool to focus on, but it might still need to be fostered in individuals with WS. Indeed, our studies have revealed that individuals with WS seem to be particularly cheerful, score low in seriousness and bad mood, have a tendency not to develop a fear of being laughed at, engage in more positive than negative humor styles, and easily laugh out loud. All these characteristics make them more likely to be able to use humor as a coping strategy. However, their intellectual disabilities (Korenberg et al., 2000), difficulties with some socio-cognitive processes (Tager-Flusberg & Sullivan, 2000) and some rules of communication (Laing et al., 2002), and their difficulties with inhibiting their spontaneous behavioral responses, might make it harder for individuals with WS to use humor efficiently in their daily life.

Future studies should, therefore, investigate the effectiveness of humor interventions aimed at helping individuals with WS use humor in everyday life and social interactions to help them cope with situations that elicit negative emotions and anxieties. These interventions could tackle their comprehension of different types of humor. One study has already revealed that humor-based therapy to cope with specific fears is effective in individuals with WS (Klein-Tasman et al., 2022), showing a promising root for future interventions and therapies using humor. As such, a second practical conclusion arising from our studies is that humor should be more thoroughly investigated in individuals with WS, to help them use humor as a coping strategy, which could reduce their anxiety level and increase their general well-being. Similar conclusions can be made for individuals with DS. Although few studies have investigated humor processing in individuals with DS, and in this thesis, they did not constitute a main group of investigation, the survey-based studies have still depicted individuals with DS as being cheerful and experiencing low levels of gelotophobia, in much the same way as individuals with WS. Future studies should investigate the specificities of individuals with DS in relation to humor to be able to drive clear conclusions on the matter; our results suggest that interventions aimed at increasing the use of humor as an emotion regulation tool might also be relevant for individuals with DS.

A last practical implication of this thesis is that it raises awareness of individual differences in humor processing, notably in relation to the subjective emotional experiences linked to specific humor types, humor styles, and laughter. Thus, people should be aware that autistic individuals and individuals with a typically serious temperament have a greater tendency to misinterpret laughter. On the other hand, individuals with WS seem to particularly appreciate laughter and humorous interactions, which indicates that it could be useful to try and adapt humorous content in such a way that they can understand and appreciate it, which could make their ability to cope through humor and build relationships through humor even stronger. Such knowledge would be useful for the personal, professional, and educational support of individuals with neurodevelopmental conditions. Everyday interactions and general communication could be adapted according to individual characteristics.

3.2.4 Future studies

Over the past decades, studies on humor in general and in neurodiverse populations seem to have grown, to allow a better comprehension of the processes involved in understanding and appreciating humor and laughter. Although existing studies on humor in ASD and WS have already contributed to describing their general humor profile, more studies are necessary to grasp even more precisely how individuals with WS and ASD interact with different types of humor. The potential area of research for future studies is very broad. As such, this section suggests just a few lines of thought for future research that emerge as a direct continuity of the present studies.

The experimental study in this thesis (Article 4) focused on the *understanding* and *appreciation* of simple humor in individuals with WS, which also seems to be the case for the other studies on humor in ASD and WS that use experimental settings (e.g., Krishan et al., 2017; Samson & Hegenloh, 2010; Silva et al., 2017; Sullivan et al., 2003; Weiss et al., 2013). Future experimental studies should also investigate the *production* of humorous content in individuals with WS and ASD. This would allow scholars to highlight the specific humor styles and sources of amusement in individuals with different neurodevelopmental conditions, to investigate what type of humor they preferentially produce. Such studies would allow us to distance ourselves from a sole normative neurotypical point of view and foster a more adapted understanding of humor in the neurodiverse population.

Further investigation into the understanding and appreciation of different types of humor in neurodevelopmental conditions would, however, still be highly informative regarding individual humor preferences and cognitive processing styles. For example, a study

by Samson and Hegenloh (2010) investigated the influence of stimuli characteristics on the understanding and appreciation of non-verbal humor in individuals with ASD who did not have intellectual disabilities. The authors presented autistic and TD participants with cartoon jokes based on different logical mechanisms and asked them to rate their level of amusement and explain the joke. The results showed that autistic individuals had more difficulty than TD participants understanding and appreciating cartoons that involved the comprehension of another character's false belief (i.e., theory of mind). Moreover, the authors revealed that when explaining the cartoons, autistic individuals had a higher tendency to refer to details that were not relevant. This appeared to be coherent with their described detail-oriented processing style. As such, this study is not only informative about the nature of humor processing but also about general stimulus processing, since it investigated the ability to apply various logical mechanisms that are based on specific cognitive competencies. Therefore, it would be highly informative to run a similar study with individuals with WS. Pre-tests would be necessary to examine whether their visuospatial difficulties prevent them from correctly processing the cartoons. If individuals with WS can process the cartoons correctly, their subjective experiences and explanations of the joke would, similarly to autistic individuals, inform us about the types of humor they prefer, as well as about the general cognitive abilities related to different logic mechanisms. It would also be interesting to investigate which elements of the pictures individuals with different conditions tend to focus on, using an eye-tracking device. This would add information to the participants' descriptions, to highlight, for example, whether individuals focus more on social or non-social elements, or on joke-related or non-joke-related elements. It would also be informative to conduct a similar appreciation/description type of experiment using *verbal* jokes that rely on different cognitive mechanisms, to examine even further our understanding of the humor and cognitive processing of individuals with WS and ASD.

To study more reliably whether individuals with WS express more laughter than TD individuals, future studies should also investigate their emotional responses in more ecological settings. In a similar manner as the study by Reddy et al. (2002), it would be interesting to videotape natural interactions between individuals with WS (as well as TD individuals for comparison) and either an experimenter or close relative, and then apply a detailed coding system similar to the one we used in Article 4 of this thesis. Such a setting would support the investigation of whether individuals with WS really tend to display a larger number of laughs and smiles, and whether these tend to be related to either humorous stimuli or social stimuli. Considering the hypersociability of individuals with WS, their supposed

tendency to smile and laugh frequently may be related to their eagerness to interact and bond with others.

For a more refined understanding of humor style preferences in individuals with neurodevelopmental conditions, future studies should use a more recent categorization, such as the Comic Style Markers (CSM) (Ruch et al., 2018a). The CSM includes eight comic styles, namely *humor, fun, nonsense, wit, irony, satire, sarcasm*, and *cynicism*, which allow a more fine-grained categorization of different humor styles than the one proposed in the Humor Style Questionnaire (HSQ; Martin et al., 2003). Previous studies have notably suggested that autistic individuals seem more able to learn how to use and understand nonsense humor than incongruity-resolution types of humor (Wu et al., 2016). Investigating the CSM in autistic individuals, for example, would highlight whether they indeed use *nonsense* humor more frequently than other types of humor. It could be expected that individuals with WS would engage more in *humor* and *fun* than in other comic styles, but this needs further investigation. Considering that the CSM questionnaire was developed for TD adults, the current self-report version cannot be adapted for individuals with intellectual disabilities. As such, it would necessitate some rearrangement to adapt the scale and its item formulation for individuals with intellectual disabilities. However, individuals can sometimes benefit from support when completing questionnaires, depending on their age and intellectual abilities, as I have experienced in my own research. As such, I would recommend distributing the questionnaire for parents to answer. Having both self- and parent-reported data would be the ideal and most efficient way of reliably assessing these comic markers in individuals with neurodevelopmental conditions.

Finally, future studies should investigate whether there might be a mismatch in the developmental stages of individuals with WS regarding the way they understand a joke and their expressive behavior. Indeed, it seems that they tend to engage more than TD individuals in laughing out loud, although they seem to appreciate jokes at a similar level. Our research, however, did not investigate their *understanding* of the humorous content. As such, the findings do not indicate whether individuals with WS appreciate the humorous content for its intended humorous meaning, or whether they find funniness in other elements of the stimuli. It would be interesting to investigate whether they understand the joke in a similar way to mentally age-matched TD participants but retain less of their spontaneous emotional responses. This would reveal a potential mismatch between the developmental stages they find themselves in, in terms of the cognitive and behavioral processes involved in humor.

3.4 Strengths and limitations

The research presented in this thesis is the first to explore and compare humor processing in ASD and WS individuals. The studies that constitute this thesis were based on the existing and fruitful literature that has investigated humor in ASD. Comparable methods were applied, to be able to examine the specificities of each condition. Although I believe in the general strengths of our findings, this research has a few methodological limitations that are important to note, to be able to interpret the results with the care they deserve. Most of the limitations are already highlighted in the studies that constitute this thesis, but a few limitations concern the research in general and are discussed in this section.

One methodological choice appears as both a strength and a limitation and concerns the fact that there is no TD group in both survey-based studies (Articles 2 and 3). Indeed, most empirical studies on individuals with neurodevelopmental conditions have a control group of TD individuals who match the group under investigation in terms of mental or chronological age. This way, it is possible to establish whether and where there is potentially a developmental delay or a particular strength. However, mental-age matching has also been criticized, notably because it favors or disadvantages individuals according to their specific strengths and difficulties, depending on which test is used to assess their intellectual abilities (Karmiloff-Smith, 2009; for a counterproposition, see for example, the developmental trajectories approach, Thomas et al., 2009). Generally, having a TD control group makes it possible to highlight what seems to be specific to a condition. As such, it would have been interesting, for example, to investigate whether the higher score for self-defeating humor in individuals with ASD compared to individuals with WS and DS was also higher when compared to TD individuals (which would suggest a particularity of ASD), or whether the difference was instead explained by a particularly low level of self-defeating humor in individuals with WS and DS compared to autistic and TD individuals.

However, in the cases of the survey-based studies, a mental age-matched group would have been quite complicated to recruit. First, since the questionnaires were sent to parents to report their child's behavior, a measure of intellectual abilities would not have been as reliable as a proper test of the individuals themselves. As such, the scores on which age-matching would have been based would not have been the most reliable. Moreover, the study was already very long for the parents, who were asked to complete 25 questionnaires in total (as discussed in the Introduction to this thesis, the data used here were part of a larger survey-based study). Therefore, estimating the participants' mental age would have

necessitated adding yet another questionnaire with a high number of items, which would have certainly increased the drop-out rate over the course of the study. A chronological age-matched group could, however, have been added to the study but was not for several reasons internal to the coordination of the study and the timeline. This being said, as mentioned above, an age-matched comparison group also has its limits and is not necessary when conducting a study on neurodevelopmental conditions. As discussed above, our findings were interpreted in line with the transdiagnostic approach, which focuses on specific strengths and difficulties rather than on the diagnosis itself. From this perspective, a TD control group was not needed to draw informative conclusions, since our groups showed specific socio-emotional characteristics, with similarities and differences, on which the interpretation of specific humor styles and the relation to others' laughter was based. As such, rather than a limitation, according to this line of thought, the absence of a control group constitutes a strength.

It is evident, also, that the use of parental ratings represents a limitation, or at least calls for a careful interpretation of the results. Indeed, the evaluation of people's behaviors and emotional experiences through the eyes of another person, no matter how close they are, cannot be as accurate as a self-rating evaluation of such phenomenon. However, studies have reported that in the case of gelotophobia, peer-ratings were consistent with self-ratings (Brauer et al., 2021, 2022). Moreover, studies have also highlighted that individuals with WS seem to reflect on their behavior differently than parents. Fisher et al. (2014) have reported that parents reflected more accurately on their child's social approach behavior than individuals with WS themselves. Consistently, Freeman et al. (2010) reported that individuals with WS had a tendency to report fewer social difficulties than their parents do, suggesting they seem to down-evaluate their social difficulties. However, the authors show similar results in self and parents-reports in relation to social strengths (such as empathy), as well as to emotional difficulties and hyperactivity symptoms. These studies suggest that parents accurately reflect on their children's emotions, behaviors and social life. However, it is probable that parents might have more difficulties in interpreting internal interpretation of specific situations. In the case of the study of gelotophobia, typically, it might be that parents reflect on their child's interpretation of laughter based on the apparent laughing behaviors of their children or their own perceived interpretation of such phenomenon. However, the potential fear of being laughed at constitutes an internal process of interpretation that is not necessarily perceivable form a third-party perspective (similarly to any fear, as long as it is not discussed with others or leading to tangible behavioral responses). Indeed, Dykens (2003)

revealed that parents of individuals with WS had a tendency to report less fears in their children than individuals with WS themselves. As such, the evaluation of the fear of being laughed at might have been underestimated by parents and future studies should investigate gelotophobia in individuals with WS using self-reports questionnaires to be able to confirm or question the findings reported in this thesis. In general, although parents-report have been shown as being consistent in the report of some behavioral, social and emotional components, the fact that Article 2 and Article 3 use *only* parents-report and do not balance such data with self-reported scores constitute an important limitation of the current thesis and calls for a careful interpretation of the results.

Another limitation concerning the groups under investigation is that the research focused on humor in individuals with ASD and WS, although two studies also included a group of individuals with DS. A higher focus could have been given to the DS group, which was considered only as a comparison group in this thesis. However, the inclusion of a group of individuals with DS also represents a strength in this research, since it allowed us to build stronger conclusions from a transdiagnostic perspective. Indeed, since individuals with DS show similarities with individuals with WS in the domains where they typically differ from autistic individuals, this methodological choice favored the interpretation of our results in line with the social motivation hypothesis. On the other hand, the choice was made not to focus on DS as an additional and isolated group of investigation, because they were not initially part of the research questions and conceptual thinking behind the research studies presented in this thesis. It seemed that it was important to remain focused on our initial goals and research design, to avoid getting lost in numerous separated interpretations that lacked a solid conceptual background. However, the findings of this research call for future and more focused investigations on humor in individuals with DS. Moreover, considering that DS is less rare than WS, researchers might be able to more easily collect data from a significant and representative sample, which would make it possible to better understand humor processing in DS, and would be a strong asset to understanding the influence of a gregarious personality on humor processing.

An important limitation of the studies constituting this thesis is that they lack a developmental perspective (Annaz et al., 2008; Thomas et al., 2009). Indeed, the age-range of the groups under investigation are quite large, and thus do not allow an interpretation based on a specific developmental stage. This issue is notably related to the lack of a chronological-age matched TD control groups in all the studies, which would have allowed for an understanding of potential developmental delay (Hodapp et al., 1990). Although, even

in the absence of a TD control group, the interpretation of the results should have focused more on the developmental trajectory of the exposed strengths and difficulties. To fully understand a specific behavioral, social or emotional pattern, it is crucial to "ascertain how the current phenotype originated at the beginning of a developmental trajectory, as well as knowing where it will lead to in the future of that developmental trajectory" (Annaz et al., 2008, p. 8). In other words, the analysis and interpretation of the data would have been more accurate if they were either integrating a TD control group, or at least a deeper investigation of differences in developmental stages. Although in the case of Article 4, the number of participants with WS was too small to allow for a deeper investigation of developmental differences, a chronological-age matched TD group would have at least allowed for an exploratory investigation of such developmental processes. In the cases of Articles 2 and 3, although we have argued above that a TD control group was not necessary to allow for a transdiagnostic approach, more thought should have been brought to the development of specific outcomes in all the groups, to highlight whether specific strengths or difficulties seem to develop at precise stages in the development of young individuals with neurodevelopmental conditions. Future studies in the field should "place the developmental process at the heart of explanations of developmental deficits" (Thomas et al., 2009, p. 355).

Other challenges and limitations raised by this thesis are related to the situation in which the research took place. As presented in the Introduction chapter, initially a few other experimental tasks were meant to constitute part of the research, but they could not be conducted due to the emergence of the COVID-19 pandemic. The section on future studies partially discusses the experimental work that could have supplemented the experiment presented in this thesis, and I hope that this will be conducted in the future. Moreover, conducting experimental research with individuals with WS presented several challenges that did not render the collection of a greater amount of data easy. First, as outlined in the Introduction, the experimental tasks required several updates to adapt them to a population with intellectual disabilities. For the three experimental tasks that were part of the beginning stage of the project, the instructions needed to be rephrased, and some stimuli needed to be either adapted or more carefully selected. More importantly, the scales used to rate participants' emotional states had to be adapted in such a way that the visual representation allowed them to understand the degrees of intensities in terms of sizes, colors, and emoticon expressions. Although proper training was built into the tasks to help TD children and individuals with WS understand the scale (see Article 4 for more details), two out of 12 participants with WS were still unable to evaluate their emotional experience reliably.

In general, I would argue that self-ratings of subjective emotional experiences might not be the most reliable source of information about the emotions of individuals with WS. Experimenters should be at least aware that this type of evaluation presents important challenges and may be difficult to process for individuals with WS. Indeed, not only do Likert scales represent a level of abstraction that is difficult for them to process, but understanding and being able to evaluate one's own emotional experience also requires important cognitive skills and can be more challenging for individuals with WS. Future experimental tasks that include individuals with WS should probably focus on more ecological settings and the analysis of spontaneous behaviors.

Additionally, we were faced with several other challenges when conducting experiments with participants with WS. One of these was that most of our participants with WS had difficulties remaining focused throughout the experimental sessions. Some of the initial experimental tasks were long (one was approximately 45 minutes) and the experimental sessions included several tasks and sometimes lasted for a few hours including breaks. We rapidly observed that, first of all, participants needed regular breaks, and second, that each experimental session could not include too many tasks or last for more than one or two hours. Even for a short 20-minute task (including instructions), such as the one presented in Article 4, most participants with WS appeared to be particularly tired at the end of the experiment, which potentially influenced the results. Their fatigue was also explained by the fact that we usually began with a test to assess the intellectual level (Raven Coloured Progressive Matrices, RCPM; Raven et al., 1990) before starting the experimental task, although we always suggested breaks between tasks.

Overall, for each task (and particularly for the intellectual level assessments), participants with WS appeared to rapidly become tired or distracted. The experimenter constantly needed to find the right balance between taking breaks and still implementing the same experimental conditions for all participants. For the experimental task on simple humor, for example, we needed to be particularly careful to ensure that participants remained focused on the computer and watched the videos correctly. Quite often, we had to impose extra breaks when we evaluated that they needed one. In the end, each experimental session could include only two tasks because of the limited time that participants with WS were able to focus without the session becoming too difficult and tiring for them. For this reason, we were unable to collect data for more experimental tasks during the allotted time for the project.

A last challenge was related to the gregarious personalities of individuals with WS. Indeed, we observed that their hypersociability led them to want to make the people they interacted with happy and feel good. In this sense, they tended to try and give answers that seemed, to them, the most appropriate for the person in front of them (i.e., the experimenter). Thus, it was an additional challenge to find the right balance between accompanying them during the task to ensure they remained focused and did not feel lost, and keeping enough distance to ensure they did not try to answer in a way to please us. Any experimental protocol including individuals with WS should take this element of their personality into account.

For the reasons explained above and in the Introduction chapter to this thesis, we were not able to conduct all the experiments that we initially aimed to conduct. To overcome the lack of experimental data, we put more focus on survey-based studies, which had the inconvenience of being less methodologically controlled but also had the important advantage of involving a larger number of participants. Hence, we were able to collect data for a significant number of participants with WS and DS, considering the rarity of the syndromes. However, when it came to participants with ASD, a larger number of participants would undoubtedly have been more informative, considering the higher prevalence of ASD. As for the experimental study (Article 4), the small sample size limited the possibility of detailed and reliable statistical analysis. As addressed in the Introduction chapter, the general health situation (COVID-19) at the time of data collection prevented us from seeing as many participants as we initially planned, given the timeline of the SNSF project and my Ph.D. Hopefully, future research will be able to involve more participants to reach more reliable conclusions.

Although the sample size was small, the study in Article 4 also presents an important strength, in that it investigated facial expressions in individuals with WS using precise coding. This coding was inspired by FACS (Facial Action Coding System; Ekman & Friesen, 1978), in the sense that the definitions of what was considered a smile or laugh were based on the action units (i.e., facial muscles) considered by the FACS to be part of a genuine smile or laugh; namely, the zygomaticus major (AU12) and the orbicularis oculi (AU6). Proper FACS coding would have required coding the videos frame-by-frame (e.g., second-by-second), to note each action unit separately, and include all the units defined in the manual (Rosenberg & Ekman, 2020). However, such coding requires suitable and official training, which neither I nor the student who coded the videos with me was able to complete. This being said, to my knowledge, our study was the first to implement such a detailed coding methodology to

examine the behavioral response of individuals with WS, and it appears to be a promising methodological area for future research on the behavioral specificities of individuals with WS.

3.5 Conclusion

Based on a fruitful line of research on humor in autistic individuals, this thesis aimed to refine our understanding of the specificities of humor processing in individuals with ASD and expand such understanding in individuals with WS. One study confirmed the particularly high prevalence of gelotophobia, the fear of being laughed at, in autistic individuals. It also showed that individuals with WS, as well as individuals with DS, seem to be protected from such a fear. The results also revealed that seriousness and bad mood, two temperament traits that lead individuals to be less inclined to engage in humorous interactions, are important predictors of gelotophobia. Importantly, these traits predict gelotophobia over and above the diagnosis of ASD itself, revealing that this is because of a particular temperament toward humor whereby autistic individuals have a higher tendency to develop a fear of being laughed at. A second survey-based study suggested that autistic individuals have a higher tendency than individuals with WS and DS to engage in self-defeating humor. That is, they seem to be more likely to use humor as a form of self-deprecation. Interestingly, one important predictor of self-defeating humor seems to be conduct problems suggesting it is related to mental health. Again, these results reveal the importance of approaching humor processing from a transdiagnostic perspective, since the diagnoses themselves no longer significantly predicted self-defeating humor once mental health problems were controlled for. Finally, an experimental study confirmed the tendency of individuals with WS to be particularly expressive when it comes to positive emotions. Indeed, our results revealed that individuals with WS tend to laugh out loud more easily than TD children.

Essentially, this thesis adds new input to our understanding of humor processing in individuals with neurodevelopmental conditions and confirms the importance of investigating this matter further, given the role that humor can play in psychological well-being. Overall, what this thesis shows is that an individual's relationship with humor varies considerably from one individual to the next. Therefore, researchers, practitioners, and caregivers should keep in mind that humor can have as much of a negative as a positive impact and that it is not necessarily understood at the same level or in the same way by every individual.

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Appendix

Appendix Table 1

Complete DSM-5-TR description of autism spectrum disorder. Retrieved from APA (2022) and unchanged.

A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by all of the following, currently or by history (examples are illustrative, not exhaustive; see text):
    1. Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.
    2. Deficits in nonverbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.
    3. Deficits in developing, maintaining, and understanding relationships, ranging, for example, from difficulties adjusting behavior to suit various social contexts; to difficulties in sharing imaginative play or in making friends; to absence of interest in peers.

B. Restricted, repetitive patterns of behavior, interests, or activities, as manifested by at least two of the following, currently or by history (examples are illustrative, not exhaustive; see text):
    1. Stereotyped or repetitive motor movements, use of objects, or speech (e.g., simple motor stereotypies, lining up toys or flipping objects, echolalia, idiosyncratic phrases).
    2. Insistence on sameness, inflexible adherence to routines, or ritualized patterns of verbal or nonverbal behavior (e.g., extreme distress at small changes, difficulties with transitions, rigid thinking patterns, greeting rituals, need to take same route or eat same food every day).
    3. Highly restricted, fixated interests that are abnormal in intensity or focus (e.g., strong attachment to or preoccupation with unusual objects, excessively circumscribed or perseverative interests).
    4. Hyper- or hyporeactivity to sensory input or unusual interest in sensory aspects of the environment (e.g., apparent indifference to pain/temperature, adverse response to specific sounds or textures, excessive smelling or touching of objects, visual fascination with lights or movement).

C. Symptoms must be present in the early developmental period (but may not become fully manifest until social demands exceed limited capacities, or may be masked by learned strategies in later life).

D. Symptoms cause clinically significant impairment in social, occupational, or other important areas of current functioning.

E. These disturbances are not better explained by intellectual developmental disorder (intellectual disability) or global developmental delay. Intellectual developmental disorder and autism spectrum disorder frequently co-occur; to make comorbid diagnoses of autism spectrum disorder and intellectual developmental disorder, social communication should be below that expected for general developmental level.